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NATURE

A Weekly Journal of Science

Vol. 184, No. 4693 SATURDAY, OCTOBER 10, 1959 2s. 6d.

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NATURE

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CONTENTS

	Page
The Development of Public Services in a Modern Democracy	1087
British Industry. By Prof. A. J. Brown	1089
Turning Points in Physics. By G. R. Noakes	1090
Catalytic Processes and Petroleum. By Dr. David M. Wilson	1090
Sex on the Farm. By Dr. S. J. Folley, F.R.S.	1091
Hæmoglobin and Sensory Mechanisms. By P. A. Merton	1092
Colour Reproduction. By Dr. W. S. Stiles, O.B.E., F.R.S.	1092
Preparation of Diamond. By Drs. H. P. Bovenkerk, F. P. Bundy, H. T. Hall, H. M. Strong and R. H. Wentorf, jun.	1094
Fasciculus limpidus nov. gen., nov. spec., a Representative of a New Group of Bacteria. By Prof. E. G. Pringsheim	1098
Biological Problems arising from the Control of Pests and Diseases. By Dr. E. B. Worthington	1100
Darwin's Illness. By Prof. S. Adler, O.B.E., F.R.S.	1102
Obituaries:	
Mr. J. T. Davey and Mr. H. J. Morris. By Dr. T. H. C. Taylor	1104
News and Views	1105
Mellon Institute	1109
Labour Turnover. By T. H. Hawkins	1110
Strontium-90 in Human Diet. By Dr. J. M. A. Tilley	1111
Immediate and Low-Level Effects of Ionizing Radiations. By Dr. Tikvah Alper	1111
Nuclear Forces and the Few-Nucleon Problem. By T. C. Griffith and E. A. Power	1113
Chagas's Disease. By Dr. J. D. Fulton	1114
Special Ceramics. By Dr. N. F. Astbury	1115
Solid State Physics. By W. M. Lomer	1117
University Grants in Great Britain	1118
Nuclear Research in Australia	1118
Conservation of English Wallpaintings	1119
Kellogg and Ney's Model of the Solar Corona. By Dr. D. E. Blackwell and Dr. D. W. Dewhirst; Prof. Edward P. Ney and Prof. Paul J. Kellogg	1120
Proton Resonance Relaxation Times in Mobile Liquids. By Dr. J. G. Powles and D. Cutler	1123
Possible Mechanism of Cysteine Protection against Radiation Cataract. By Mrs. A. Pirie and L. G. Lajtha	1125
Release of Adenosine Triphosphate and Serotonin from Injured Cellular Blood Elements in Extracorporeal Circuits. By Dr. H. S. S. Sarajas, Dr. R. Kristoffersson and Dr. M. H. Frick	1127
Amplitude-Modulation Radio-telemetry of Nerve Action Potentials. By Roger M. Morrell	1129
Composition of a Paraffin Wax Fraction from Tobacco Leaf and Tobacco Smoke. By Dr. W. Carruthers and Dr. R. A. W. Johnstone	1131
Hæmoglobin *P* in a Family in the Belgian Congo. By Dr. Paulette Dherte, Dr. H. Lehmann and Dr. J. Vandepitte	1133
β-Globulin Alleles in Some Zebu Cattle. By G. C. Ashton	1135

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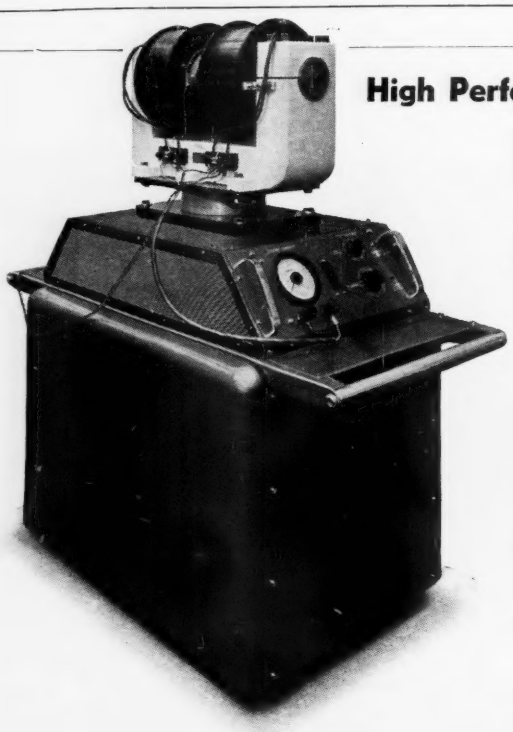

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THE DEVELOPMENT OF PUBLIC SERVICES IN A MODERN DEMOCRACY

TWO of the most valuable chapters in Dr. Brian Chapman's recent book, "The Profession of Government" (London: George Allen and Unwin, Ltd., 1959. 28*s*. net), are those in which he discusses the public service trade unions, and the relations between public officials and the public. The two subjects are closely connected, and in the compass of little more than a score of pages Dr. Chapman focuses attention on some problems of vital importance to the functioning of a democracy, of which there is little evidence that administrators, professional associations or the public generally are aware. Nevertheless, upon the effective solution of such problems the wise use of scientific and technical resources and the very possibility of creative leadership, in the service of the State or elsewhere, may largely depend.

Dr. Chapman goes unerringly to the root of the problem with public service trade unions. All the evidence points to the truth that people employed in government service tend to become not only self-governing but also self-employed. Moreover, the strength of these unions is in the lower ranks, and while in these grades parity with outside employment has been maintained, financially there is a genuine conflict of interest between the various grades of the public service. Unions representing the lower- and middle-grade officials will not accept a policy of discriminatory rises for particular grades, and for this financial reason alone, the higher public officials insist on special representation.

Now, while the European public services have acquired most of the characteristics of a profession, even for the higher Civil Service in Britain there is no recognized professional qualification or any general acceptance that the profession should have a monopoly of government. The acquisition of a recognized public status and the growth of professional training schemes in the Civil Service only partly compensate for this lack of a professional qualification. Furthermore, the professional ways of thought of public officials, more especially the senior officials, are distinctive, imposed on them by the nature of their duties; and while generally such officials are naturally affected by the way the public regard them and, in consequence, by the underlying philosophy of society and the State reflected in a country's view of public administration, Dr. Chapman's comparative survey points to a surprising similarity in attitudes in senior public officials in all European public services.

Dr. Chapman emphasizes the dependence of these attitudes on the nature of the official's duties and not on his social class. In all the countries covered by him, the public official is in social terms a typical member of the middle class; but there are few reliable statistics on the social origins of public officials in Western Europe and it is not possible to prove that public service is a factor in social mobility. It is certain, however, that social class in the public service does not work in reverse. The sons of members of the administrative class are practically never found lower down the scale; unless they can join at their father's level, they enter another profession. It is also clear that the working class and the agricultural population are both under-represented at all levels of the administration in comparison with their proportion in the population.

Nevertheless, Dr. Chapman's survey suggests that this question of social origin is relatively trivial, in comparison with the decisive influence of professional duties on their attitudes. Indeed, social class and their duty to society, as well as the nature of their work, alike make senior officials conservative, and their first preference is to keep the peace and maintain the *status quo*. In spite of this, they sympathize with efforts to remove the worst or most noticeable abuses in the fields of government which are their direct concern. Dr. Chapman points out that they, frequently more so than politicians, are aware of the black spots of society, even though their knowledge may be second-hand, and that this instinct for improvement has been responsible for many minor social and industrial reforms throughout Europe, particularly in the newer fields of government. Most frequently, however, the instinct to improve is confined to the official's special field.

It is inherent in this that senior officials should incline to believe that they are more disinterested, intelligent and far-sighted than other people engaged in government, and this is due not so much to authoritarianism as to the distrust of the professional for the enthusiastic amateur. Again, awareness of public responsibility and of the impossibility of full impartiality and equality of treatment can also lead to a clash between professional and amateur, and to divergence between official and public. The official is aware that he has to deal with a world that is neither efficient, rational nor equitable, and distrusts the claim that the public has an inalienable right to efficiency, impartiality and rationality. He is also better aware than the public of inconsistencies which may mar their mutual relations.

All this bears profoundly on the two questions which Sir George Schuster discusses in his review of the working of the National Hospital Service in Britain, entitled "Creative Leadership in a State Service"*. Can a State-directed service be an instrument of dynamic progress and provide scope for individual enterprise and initiative? Can State-directed 'welfare' measures produce true welfare—that is, welfare judged according to a standard of values appropriate to a modern society? These

* Creative Leadership in a State Service: a General Survey. (Hospitals and the State: Hospital Organization and Administration under the National Health Service, Sixth and final Research Paper.) Pp. iii+80. (London: Acton Society Trust, 1959.) 4*s*.

questions, however, may be considered in the light of three major points which Dr. Chapman makes as the outcome of his review of Western Europe as a whole.

First, in every country the increase in public services has not been accompanied by sufficient serious thought as to the best way of absorbing them into the structure of the modern State. The haphazard creation of semi-public, public, quasi-private and partly autonomous bodies complicates law, operation and control. Secondly, clarification in this field might help to disentangle some of the more acute problems of public service law. There is no sensible reason, Dr. Chapman suggests, why a postman should be a Civil servant and a gas inspector or railway driver should not. Nor is there any serious reason why the vast mass of manipulative, clerical or even executive staff employed in public administration, whose duties are exactly comparable with those in private employment, should not be engaged on private law contracts. A much more vigorous distinction in public administration between public officials and private law employees would both simplify public service law and permit an element of flexibility in personnel matters which is lacking in many countries, and also allow the general unification of the public services to be considered seriously. This is particularly important at the higher levels, where it should promote a proper balance between administrators, managers and technologists, and remove some of the anomalies which disturb the Institution of Professional Civil Servants. It might well be reconsidered whether the chemist, the physicist, the engineer, for example, engaged on professional duties in the Government service, need necessarily be a Civil servant unless those duties include public administration.

Thirdly, Dr. Chapman remarks that the recent awareness of the need for better government public relations has gone no further than communicating to the public what the public service concerned is doing, rather than why it is doing it. This is an essential to informed public discussion, but in his reasoned attack on the secretiveness of British Government methods, Dr. Chapman is too concerned with the negative effects of secrecy to emphasize the positive contribution of informed discussion to the functioning of democracy. In Western democratic theory, government is the task of representatives of the electorate, and no growth in the complexity of the tasks of government can make government the task of a profession; it can only emphasize the responsibility of the professional administrator for seeing that the implications and consequences of particular decisions and policies are clearly understood by the elected representatives.

The relevance of Dr. Chapman's observations and suggestions to the problem of creative leadership which Sir George Schuster discusses in the context of the National Health Service in Britain is apparent from the start of Sir George's analysis. That analysis follows on a general survey of hospital organization and administration under the National Health Service made by the Acton Society Trust, which vindicated the Government's original purpose to allow the fullest possible decentralization of the Hospital Service. While this should be maintained, the Acton Society Trust points out that the Ministry is still left with a responsibility it cannot abdicate—that of giving inspiring leadership and guidance, interpreting the lessons of decentralized experience and involving national resources for dealing with the problems that can only be effectively handled on a national basis. In particular, the Trust's survey led to the conclusions that not enough had been done to study and interpret current experience; that a frequently changing junior political Minister is ill-placed to satisfy the need for continuous inspiring leadership in a great operating service; that the Ministry as at present organized does not provide a staff containing enough men with the right kind of knowledge based on practical experience in the field; that the staff is itself hampered by lack of an adequate statistical and intelligence service, and that the Ministry's advisory bodies cannot fill the gap.

Sir George Schuster begins with Mill's prescription—the greatest dissemination of power consistent with efficiency but the greatest possible centralization of information and diffusion of it from the centre, and with Mill's dictum that a Government cannot have too much of the kind of activity which does not impede but aids and stimulates individual execution and development. In emphasizing, however, the intensely human character of a health service and the large number of voluntary unpaid members concerned in its control, Sir George directs attention to two further questions which arise out of those to which he was asked to give special attention. First, how—by what working methods and arrangements—can the preservation of the voluntary spirit of service which is embodied in the boards and committees of management be most effectively combined with adequate power for the Minister to discharge his responsibility to Parliament for ensuring efficiency and economy in the expenditure of public money? Secondly, how can the professional freedom of medical practitioners and surgeons, on whose skill the work of the hospital service ultimately depends, be reconciled with the just claims of public authority?

Obviously, these are essentially the questions that arise in regard to public expenditure on research and on the universities, and the answers Sir George Schuster suggests are of great interest to those concerned with the functioning of the University Grants Committee, public accountability in the nationalized industries and the deployment and balance of the national effort in scientific and industrial research and the control of expenditure in that field. They are questions of far-reaching importance which should be a prime concern of the newly appointed Minister with special responsibility for scientific effort in Britain. Moreover, while Sir George Schuster does not deal to any extent with the question of professional freedom, he has raised a general issue which demands the attention of professional bodies generally, and the importance of which in its broadest context has also been admirably stated by Sir Solly

Zuckerman in his recent address (see *Nature*, July 18, p. 135) delivered at the California Institute of Technology.

It is no disparagement of the importance of the National Health Service to suggest that Sir George Schuster's pamphlet is of even wider public interest in the context of the problem of government generally, the place and use of the expert in public affairs, the responsibilities of professional organizations and the functions and staffing of the Civil Service. Like Dr. Chapman, he displays issues where fresh thought is urgently required, practices which require critical and independent examination, and preconceived ideas and even traditions which should be challenged. It is to be hoped that the place of his pamphlet in the survey of the National Health Service made by the Acton Society Trust will not lead other professional associations, or indeed the scientist and technologist generally, to miss the challenge to creative leadership which he offers to them no less than to the medical profession itself.

BRITISH INDUSTRY

The Structure of British Industry

A Symposium. Edited by Duncan Burn. Vol. 1. Pp. xvii+403. 45*s*. net. Vol. 2. Pp. xii+499. 50*s*. net. (National Institute of Economic and Social Research.) (Cambridge: At the University Press, 1958.)

FOR a long time the best general account of the main British industries in a single book has been Prof. G. C. Allen's famous work, "British Industries and their Organisation", first published as long ago as 1933, though modernized in successive editions since. The two volumes here under review constitute, therefore, the first new major attempt for a long time to provide something which, in principle, every British student of economics (and many overseas students) would like to have.

As a new standard text-book and work of reference, this book has very great strength, but also, inevitably some weaknesses. Its strength is that it calls upon an extremely able team of writers, many of them fresh from, or still engaged in, the task of writing larger monographs on the industries which they here discuss; the rest, who have made investigations for the sole purpose of their contributions to this symposium, remarkably well-selected and successful. Its weakness is that it lacks the uniformity which can be achieved by a single author, asking roughly the same questions about a number of industries. Apart from setting out the facts of size and number of firms, the different contributors adopt a variety of approaches which makes the editor's gallant effort to treat some matters of general interest in his final chapter a difficult one. The student may also find the size and cost of this important work formidable.

It would be wrong, however, to judge it merely as a text-book. It is an important fact about economic studies that in the past decade or two, while at their theoretical end they have been accused of becoming more difficult for the practical man to understand, they have undeniably gained enormously in realism through economists consorting with practical men, either as Civil servants or as students of industrial problems in the field. No one man can nowadays attain to comprehensive first-hand knowledge of a wide range of industries, as Alfred Marshall was able to seventy years ago—hence the necessity for a symposium—but the intimacy of the knowledge attained by the contributors, and the fundamental nature of the questions which some of them attempt to answer on such matters as pricing policy, are evidence of the increased penetration of economists generally into the realities of industrial life.

A list of the industries dealt with shows the wide scope of these volumes: agriculture, building, road and rail transport, coal, oil, chemicals, steel, building materials, machine tools, motors, aircraft, shipbuilding, electronics, cotton and rayon textiles, woollen and worsted, man-made fibres, pottery, pharmaceuticals, and cutlery. It suggests, too, the variety of different 'atmospheres' to be dealt with, ranging from those dominated by State policy, as in the case of agriculture and aircraft production, to the predominantly private commercial atmosphere of, for example, the pottery industry; or from ferments of technological change, as in electronics or pharmaceuticals, to the static environment of wool textiles. It need scarcely be said that the nature, possibility, and meaning of competition vary enormously from one industry to another. The more closely one looks at most industries (even those which are in some sense the most 'competitive'), the further they appear to lie from the old model of 'perfect' competition between firms making exactly similar products. The nearest simple model of wide application, indeed, would seem to be that of 'oligopolistic' competition, between firms which compete directly (or not quite directly) with a fairly small number of others—though with the important reservations that 'potential' competition, often from users of the product who might turn to manufacturing it themselves, is frequently just round the corner, and that the weapon of competition is increasingly often an improvement in design rather than a reduction in price. Nearly everywhere there is some evidence of increasing concentration, but in very many places the small firm is remarkably viable, not by any means always for the same reason. Where concentration has gone so far as to create monopoly power, it becomes very evident that this power, though it may not be harmless, is subject to a variety of checks, quite apart from those imposed by legislation. The case of coal, where absolute monopoly is itself the product of legislation, shows how powerful the restraint imposed by competition from quite different products can be.

The question how far the structure of British industry conduces to high and increased efficiency is one which, again, admits of no simple answer. The very general impression, indeed, is that the adjustments of the past twenty years have been made with reasonable smoothness and with gains of efficiency which are often striking. This, however, should not lead the reader into complacency. The contributors to this work have the relatively pleasant task of portraying British industry on the favourable wicket of expansion in the national economy and in world trade. It is a very different story from the agonizing chronicle of difficult contraction in so many of the basic industries between the Wars. It may be as well to reflect that, while we may hope never again to see general stagnation of the economy or a major depression in its total activity, we have given a number of hostages to fortune in, for example, motors and shipbuilding, which may find how much more difficult it is to be progressive in adversity than in prosperity.

A. J. BROWN

TURNING POINTS IN PHYSICS

Turning Points in Physics

A Series of Lectures given at Oxford University in Trinity Term 1958. By R. J. Blin-Stoyle, D. ter Haar, K. Mendelssohn, G. Temple, F. Waismann and D. H. Wilkinson. (Series in Physics.) Pp. v+192. (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1959.) 20*s*.

DURING Trinity Term, 1958, a series of lectures was organized by the Reader in the Philosophy of Science and the Lecturer in the History of Science in the University of Oxford. The lectures, collected in this volume, are: (1) "The End of Mechanistic Philosophy and the Rise of Field Physics", by Dr. R. J. Blin-Stoyle; (2) "The Quantum Nature of Matter and Radiation", by Dr. D. ter Haar; (3) "Probability enters Physics", by Dr. K. Mendelssohn; (4) "From the Relative to the Absolute", by Prof. G. Temple; (5) "The Decline and Fall of Causality", by F. Waismann, and (6) "Towards New Concepts: Elementary Particles", by Prof. D. H. Wilkinson. The audience to whom they were originally addressed was composed of philosophers and scientists who were not physicists. The publishers suggest that they can be understood by laymen; I have the word of an historian colleague, who recommended the book with great enthusiasm for the general library, that this is so. He had some reservations, it is true, about grasping all the points raised; and it is not exactly light reading, even for the scientist. As an account of the origins and development of the present state of theoretical physics it is most stimulating; and to be able to communicate so much of the physicist's outlook at a non-specialist level is a magnificent achievement.

The title "Turning Points" is itself significant. Thirty or forty years ago classical physics was spoken of in rather dismal terms of 'downfall'; by inference, the supplanting modern physics was undergoing uplift—and it apparently did, quite out of this world. But the outcome of all this has not been depression or exaltation; nothing less than a complete reorientation of all our ideas has been necessary, and this turning has not really been a sudden event. As the first lecture points out, the fulcrum was effectively set up by Faraday; and the statistical approach goes back nearly as far—but applied only to classical particles. The quotation from Niels Bohr—"My method is to try to say what I cannot say, because I do not understand it"; Dr. Waismann's statement that quantum physics presents a strong case against traditional logic; and Prof. Wilkinson's remark that the first stumbling block for people who want to understand the elementary particles is that some of the things they learn run counter to common sense, between them emphasize the kind of turning that is demanded. In the macroscopic world of everyday life, we can 'understand', use classical ideas, relate matters as 'cause and effect', work to the rules of logic, and be guided by common sense. In the microscopic world of atomic physics, none of these things can happen. The physicist has to live a life of double-dealing between two worlds—observing with macroscopic apparatus, and interpreting in terms of microscopic concepts which have no counterparts in ordinary life, either in essence or in behaviour. Each of the lectures shows clearly the terms of reference within which modern physics operates.

Rule out causality, mechanical particles, identifiable individual particles, and the appeal to analogy taken from everyday life, and what is left of the microscopic world except concepts that can only be handled as mathematical abstractions? The question, which is the real difficulty facing the ordinary reader (and most of us older physicists as well), is squarely met in the contributions of Prof. Wilkinson and Prof. Temple. The answer is, generally, invariance or symmetry or conservation conditions and 'properties' (if that is the term) to which such conditions can apply—such as Newton's third law of motion (Temple) or the conservation of isotopic spin (Wilkinson), which seem indeed to have much in common.

Illustrations and examples strike a fresh and original note. The derivation of the Lorentz transformation (Temple) is neater and simpler than that in the text-books. The conflict between causality and the uncertainty principle (Waismann) is illustrated by idealized experiments, and numerous examples of the application of the principle are given. The account of the elementary particles (Wilkinson) is both up to date in content and superb in its clarity; the author does not, of course, lament that physicists are large compared with m_e, and long-lived by K-meson standards—but he mentions that this immense difference in scale prevents us from even being able to describe the microscopic world in ordinary language at all. The lighter touches and personal reminiscences that drop into place here and there suggest that the authors were thoroughly enjoying their task; they must have done, to be able to accomplish it so brilliantly. G. R. NOAKES

CATALYTIC PROCESSES AND PETROLEUM

Catalysis

Edited by Prof. Paul H. Emmett. Vol. 6: Alkylation, Isomerization, Polymerization, Cracking and Hydroreforming. Pp. vi+706. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 156*s*. net.

THIS volume is the penultimate one in this very comprehensive series; it deals with the catalytic processes that have now such an important place in the petroleum industry. The editor is to be congratulated on this further stage of his monumental task and in particular on achieving a very reasonable uniformity of treatment in the six 'chapters' written by eleven authors. Each chapter forms a clearly defined section dealing with an important refinery operation involving catalysis and comprising alkylation (with 59 references), isomerization (322 references), polymerization of olefines (212 references), catalytic cracking (126 references) and reforming (164 references), together with a chapter on the mechanism of polymer formation and decomposition (374 references). The large number of references makes the volume a valuable starting point for further study, particularly to chemists entering the petroleum and petrochemicals field. At the same time the authors have accepted the responsibility of surveying this mass of literature and presenting it as a coherent account and not simply as a collection of abstracts.

Earlier volumes in this series dealt, of course, with the fundamentals of catalysis, so that the authors here are free to deal with the more specialized and prac-

tical aspects. This still leaves a large field to be covered and in most cases the authors set clearly defined limits to the subjects they discuss.

Alkylation is dealt with in a clear and concise manner, and the comment in this chapter that "the development of a body of knowledge in alkylation embraces in chronology the development of highly precise analytical distillation methods and spectroscopic identification methods for hydrocarbons" can apply to each chapter in turn. It is interesting, though possibly fruitless, to speculate on the course of events if our modern techniques of hydrocarbon analysis had been available to the pioneers in this field.

In the chapter on isomerization, a much more complete treatment is attempted under the headings "General Aspects and Mechanisms", "Kinetics" and "Equilibria". The treatment is very systematic and will be of particular value to research workers entering this field. It is irritating, however, to find bracketed explanations such as "BF_3 (boron trifluoride)" and even "I_2 (iodine)" in a book of this type. The chapter on mechanisms of polymer formation and decomposition follows, its scope being clearly defined and topics such as polycondensation, co-polymerization and hydrolytic and enzymatic cleavage reactions are included. This is an excellent survey of the specified fields. Polymerization of olefines is the subject of the next chapter, the presentation being limited to liquid polymers only, ranging up to lubricating oils and viscosity index improvers. After an excellent discussion of the thermodynamics and mechanisms, commercial processes are dealt with in moderate detail. The behaviour of pure hydrocarbons is the main theme of the chapter on catalytic cracking, the commercial processes being discussed only briefly. This again is a necessary limitation in such a wide field. A list of twelve phenomena is given, which it is suggested an acceptable theory of catalytic cracking should explain. The poisoning action of nitrogen bases, a discussion of which immediately precedes the list, might well have been added to it. The final chapter, on catalytic reforming, includes a good deal on the commercial processes and is again a valuable survey.

The printing and diagrams are up to the high standard one expects, and the volume will certainly join the others of the series as an important contribution to the literature of chemical industry in the widest sense.

DAVID M. WILSON

SEX ON THE FARM

Reproduction in Domestic Animals

Vol. 1. Edited by H. H. Cole and P. T. Cupps. Pp. xv+651. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 14.50 dollars.

THIS book, when the second volume is published, will have to stand comparison with such well-known treatises as "Allen's Sex and Internal Secretions", a third edition of which is in preparation, "The Hormones", edited by Pincus and Thimann, and, above all, "Marshall's Physiology of Reproduction", publication of the third edition of which began in 1952 and is not yet complete.

The present volume opens with two chapters on the anatomy of the male and female reproductive organs and is thereafter almost wholly concerned with the female. There are four chapters, three of which are of a fundamental nature, dealing with the role of various hormones and of the nervous system in reproduction. After five chapters describing the œstrous cycle of farm animals and the bitch (apparently the cat is not considered a domestic animal), fertilization, implantation, the physiology of the placenta and pregnancy, and parturition are covered in four chapters. The volume ends with a chapter on lactation.

In the space available it is impossible adequately to write a critical appreciation of so important a book; all that can be done, at the risk of appearing invidious, is to refer to those topics which particularly interest the reviewer. He well remembers the absorbing interest with which he read in 1939 C. G. Hartman's outstanding chapter in "Sex and Internal Secretions" (second edition). Does the present volume contain a chapter comparable with this? This is scarcely to be expected since the power to write so vividly is unfortunately rare. Perhaps C. W. Emmens's contribution on the role of the gonadal hormones in reproduction comes closest, for it is written in a flowing style and deals lucidly with a complicated subject. Miriam E. Simpson gives an authoritative and well-written account of the pituitary and other gonadotrophins, though her treatment of the subject might appear to be orientated towards man rather than farm animals. C. W. Turner's chapter on the thyroid, adrenal cortex and posterior-pituitary hormones is something of a mixed bag, heavily over-shadowed by a discussion of practical applications of thyroid physiology in the domestic fowl and farm animals, a subject which might well have been assigned a chapter on its own. The adrenal cortex and posterior-lobe hormones could easily have been expanded to separate chapters. T. J. Robinson's contribution is noteworthy for an interesting and largely first-hand account of how the œstrous cycle of the ewe can be manipulated hormonally with the view of increasing fertility; it includes a short section on the 'doe' which, despite the "Shorter Oxford English Dictionary", turns out to be the female goat. The brevity of this section reflects the paucity of experimental work on this species and it is the more surprising that a ten-year-old paper by the reviewer and his colleagues on out-of-season breeding was overlooked. J. Meites contributes a comprehensive review of mammary physiology with much of which the reviewer has little quarrel, though two points merit mention. Even considering that the chapter must have been written nearly two years ago, it is surprising to learn that somatotrophin has no major role in mammary growth, and also to see cogent evidence for a role of oxytocin in the release of prolactin dismissed so summarily.

A book of this nature must be considered as a whole rather than as a collection of isolated essays, and if it is to be successful, the editorial guiding hand must be all-pervading, if unobtrusive. One criticism of the present book is that there is too little evidence of editorial co-ordination. For example, posterior-pituitary hormones, principally oxytocin, are dealt with in several chapters but with little cross-referencing; the same applies to relaxin. The value of the book to the reader would have been much enhanced had adequate cross-references been given in these and many other instances. A number of other blemishes could have been eliminated by sterner editorial action. There are infelicities such as the use of "beef" and "pork" to describe pituitary glands from the ox and pig (yet "mutton" is not

used for sheep pituitaries, as it should have been for consistency), and the widespread use of the inept term "let-down" which the reviewer thought he had knocked out twelve years ago, but which has persistently refused to lie down. There are some inconsistencies such as the use of "dog" rather than "bitch", while the females of the ox, horse, sheep and pig are called "cow", "mare", "ewe" and "sow". Bibliographical errors are also more frequent than they ought to be, particularly in Chapter 7. British readers are by now inured to what seems to be becoming standard American practice in the use of prepositions (two of the more startling examples being "identical to" and "different than"), but in a book of this calibre one would not expect to find a sentence like (p. 163): "A hypothyroid monkey put on a very low thyroid dosage for a period of ten days always resulted in the return of menstrual function".

The main justification for the publication of this book in face of the well-established and authoritative treatises mentioned at the beginning of this review must lie in its emphasis on farm animals and its relatively modest price, which will bring it within the reach of the private purchaser. Is this publication justified? On the showing of this first volume the reviewer thinks so, despite the criticisms mentioned above, and he is glad to recommend it.

S. J. Folley

HÆMOGLOBIN AND SENSORY MECHANISMS

Progress in Biophysics and Biophysical Chemistry

Vol. 9. Edited by Prof. J. A. V. Butler and Prof. B. Katz. Pp. vii+388. (London and New York: Pergamon Press, 1959.) 105*s*. net.

FOLLOWING the present reviewer's criticism in *Nature* of the previous volume of this series on the grounds that few of the articles matched up to the aims stated in the preface, the editors have prudently suppressed the customary preface in this volume. Perhaps they need not have feared; their aims may well be achieved, for five out of the seven articles are written in such a way as to be intelligible and interesting to non-specialists in their subjects. Two of these articles have the special flavour that only comes when a scientist with a flair for exposition describes the development of a subject he has himself largely invented and contributed to. These are F. J. W. Roughton on the kinetics of oxygen and carbon monoxide uptake by red cells and by solutions of hæmoglobin, and W. A. H. Rushton on visual pigments and their measurement in the living human eye. The book opens with an enthusiastic and highly interesting account by Q. H. Gibson of the rapid reactions of hæmoglobin with gases. The last article which can be recommended without reservations as to style or scientific content is that in which J. A. B. Gray describes what is known of the way sensory endings, sensitive to mechanical change, convert mechanical energy into streams of nervous impulses; he illustrates the argument mainly from his own and his collaborators' pioneer work on the Pacinian corpuscle.

It would have been churlish to exclude the article by D. A. McDonald and M. G. Taylor on the hydrodynamics of the arterial circulation from the category 'intelligible and interesting', but after reading it I found I was not convinced either that their problem was an important one, or that they had advanced much towards a solution.

The two remaining papers are by A. Peterlin on molecular dimensions and light scattering (fifteen pages of references) and by C. de Duve, J. Berthet and H. Beaufay on gradient centrifugation of cell particles. Both of these appear to be competent and clear descriptions of the theory and practice of their highly specialized techniques, which would no doubt be of great convenience to anyone directly concerned. But this volume is supposed to be about progress. Is a technical description of the methods by which progress may have been achieved in the past and by which it is hoped to achieve it in the future any substitute for a critical account of progress? It certainly makes very much duller reading than the real thing. Fortunately, there is plenty of the real thing in this mainly excellent work.

P. A. Merton

COLOUR REPRODUCTION

The Reproduction of Colour

By Dr. R. W. G. Hunt. Pp. 208+10 plates. (London: Fountain Press, 1957.) 63*s*. net.

THIS book expounds the principles and the crucial technical devices of the processes used in colour reproduction in photography, printing and television. Many of these processes are now extremely intricate—for example, the action of the couplers of various kinds used in colour photography and the coding and transmitting of colour information on television wave-bands of limited width. In the difficult task of explaining essentials in an easily read text with clear and simple diagrams and a minimum of mathematics, the author has been highly successful. A course of lectures (Royal Institution, 1953) was the starting point and much of the freshness and intimacy of a good lecture style has been preserved.

A common element linking all the reproduction techniques is a dependence on the basic ideas of colorimetry and the perception of colour by the human eye, fields in which Dr. Hunt's own researches are well known. The exposition here is unexceptionable and, most important, it has not been allowed to expand unduly so as to upset the balance of the work. Colour reproduction techniques, in their primitive form, are not capable—even theoretically—of giving exact reproduction, and much of what Dr. Hunt has to say concerns colour correction methods: the nine-page chapter on the general masking method in photography and the discussion of developments from Neugebauer's analysis of dot image reproduction in printing are particularly informative brief-accounts. The difficulties of assessing the 'quality' of the final result in colour reproduction are well brought out, with emphasis on the inadequacy of a demand for a simple point-to-point correspondence with the original.

Although the book appears to be addressed mainly to a rather lay circle, that is to say, people having to do with colour pictures in various ways but not experts, it is certain that many readers, knowledgeable in one area of the wide field covered, will find most useful this insight into related techniques. In the quality of the coloured plate illustrations the publishers have not failed the author. W. S. Stiles

Excursion Flora of the British Isles

By A. R. Clapham, T. G. Tutin and E. F. Warburg. Pp. xxxiii+579. (Cambridge: At the University Press, 1959.) 22*s*. 6*d*. net.

THIS volume has been developed from Clapham, Tutin and Warburg's "Flora of the British Isles", published in 1952, by curtailing descriptions to little more than is needed for identification, by omitting all information not strictly relevant to identification, by omitting most of the rarer mountain species and by simplifying the accounts of such critical genera as *Rubus* and *Hieracium*. The result is very considerably to reduce the time taken in using the keys and substantially to cut down the number of wrong turns that a beginner can take. The book also is a bare three-quarters of an inch thick as against the solid two inches of the original.

In practice, it has been found that even a beginner can identify plants satisfactorily with the aid of the excellent glossary, which has been retained from the original work, and the authors must be congratulated most warmly on having produced such a practical book with up-to-date nomenclature and equally up-to-date information. In these ways their work is beyond criticism. There are, however, two gaps to be filled. The first is illustrations, and this could easily be filled by a companion volume taken from the illustrations to the larger volume, by Sybil Roles, Vol. 1 of which has already appeared. Her line drawings, in this case with only one to the page and with only those species here included, would make an invaluable supplement. Our other need is for a student's flora in Hooker's sense. The present volume could easily be modified for this purpose by the addition of something comparable to Hooker's synopsis of natural orders and natural arrangements of families.

P. FALK

Soil Chemical Analysis

By Prof. M. L. Jackson. Pp. xiv+498. (Englewood Cliffs, N.J.: Prentice-Hall, Inc.; London: Constable and Co., Ltd., 1958.) 57*s*. 6*d*. net.

THE seventeen years that have elapsed since the publication of Piper's "Soil and Plant Analysis" have seen rapid advances in the subject of soil chemical analysis, notably by the widespread adoption of spectroscopic techniques, and a considerable need has been felt in recent years for an authoritative up-to-date treatment of methods of soil analysis. It is fortunate that Prof. Jackson has undertaken the task of meeting this need, because his diversity of interests and long experience of the complex problems of soil analysis have enabled him to write a book that is much more than a collection of recipes. Within the compass of 500 pages he deals adequately with nearly all the techniques employed in modern soil chemical analysis and also finds space for alternative methods of analysis. This coverage has been achieved by judicious selection of methods and references, concise writing, and good organization of the subject material (every paragraph is numbered to permit cross-reference).

It is easy to criticize a book of this type, and some analysts will undoubtedly question the omission or inclusion of certain procedures. There are a considerable number of typographical errors, the index is rather inadequate, and the relevance of some of the quotations under the chapter titles is obscure. However, these are minor defects, and this work deserves praise rather than criticism. The book is well illustrated, reasonably priced and generally well produced, although a more suitable type of paper could perhaps have been found for a book that seems destined to spend much of its life on laboratory benches.

This work is indispensable to anyone concerned with soil chemistry. It should be particularly welcome to teachers, because it includes suggestions for a laboratory course, pertinent questions at the end of each chapter, and admirably concise discussions of the principles of various methods.

J. M. BREMNER

Curare and Curare-Like Agents

Edited by D. Bovet, F. Bovet-Nitti and G. B. Marini-Bettolo. Pp. xi+478. (Amsterdam: Elsevier Publishing Company; London: D. Van Nostrand Company, Ltd., 1959.) 85*s*.

THIS book is the outcome of an international symposium held in Rio de Janeiro in August 1957. It is very different from previous monographs on curare and from the now familiar pattern of conferences of which the names of the participants can almost be predicted from the title: both the wide scope of the book and the large number of contributors from South American countries are welcome innovations. The home countries of the curare alkaloids have provided specialists reporting on the botany, history and ethnology of curare, on the methods used to prepare the poisoned arrows, on the survival in present days of the use of curare for hunting purposes. Other parts of the book deal with classical organic chemistry, pharmacology and clinical uses of curare and its synthetic substitutes; there are fascinating speculations on the receptor–drug interaction, which is no longer considered as a stable equilibrium but as a dynamic process in which not only the drug but also the receptor may suffer deformation and therefore changes in the course of time. The book is well produced; the autoradiographs (in P. G. Waser's article) of end-plate regions of muscle poisoned with decamethonium are particularly beautiful.

MARTHE VOGT

Outline of Historical Geology

By A. K. Wells. Fourth edition revised with the assistance of J. F. Kirkaldy. Pp. xv+398. (London: George Allen and Unwin, Ltd., 1959.) 32*s*. net.

A. K. WELLS'S "Outline of Historical Geology" was first published in 1937, and was then intended as an introduction to the stratigraphy of Great Britain for the general reader presented in such a way as to stress the cultural or philosophical value of historical geology. Later editions, written with the assistance of J. F. Kirkaldy, enlarged the scope of the work to make it more suitable for the use of students reading for a degree in geology or geography. In the present, fourth, edition, further improvements and additions have been made. A new chapter has been included on the Pre-Devonian rocks of Scotland, which incorporates the results of recent research on Highland stratigraphy and structure. New data on the Pre-Cambrian of Shropshire, on the nature of the chalk, and on the Wealden 'delta' are also included among the revisions that have been made. Selected references now appear at the end of each chapter. Despite the pressure of new facts, the authors have contrived to maintain the emphasis on principles, in accordance with the aim with which the first edition was introduced, rather than the mass of detail into which the teaching of stratigraphy can too easily degenerate.

PREPARATION OF DIAMOND

By Drs. H. P. BOVENKERK, F. P. BUNDY, H. T. HALL*, H. M. STRONG and R. H. WENTORF, jun.

Chemistry Research Department, General Electric Research Laboratory, Schenectady, New York

IT would be good to be able to write a paper entitled "The Preparation of Diamond", in which all the factors affecting diamonds were nicely accounted for and the formation of diamond was completely explained. But the work which has been carried out on this problem indicates that diamond can form in several different ways, and that stubborn mysteries still surround some of them. This article, therefore, is more of the nature of an interim report which describes the salient features of the knowledge obtained so far rather than a complete exposition of diamond formation.

All the observed cases of diamond preparation in our laboratory have occurred at pressures and temperatures appropriate for the thermodynamic stability of diamond. Fig. 1 shows a diamond–graphite equilibrium curve. For temperatures up to 1,200° K. the path of the curve has been estimated by Rossini and Jessup[1], Simon[2] and others from thermodynamic data. For temperatures between 1,500 and 2,700° K., the path of the curve has been determined experimentally by observations of the growth or disappearance of small diamond crystals immersed in suitable media[3].

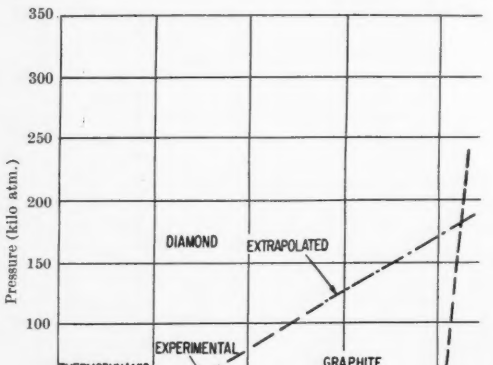

Fig. 1. Carbon phase diagram

The experiments which form the basis for most of this article were usually performed in a tapered piston apparatus capable of very high pressures which enabled us to attain diamond stability at high temperature. Figs. 2*a* and 2*b* illustrate the tapered piston 'belt' apparatus which will be discussed in detail by H. Tracy Hall in a separate paper submitted for publication. Many of the most promising systems were examined at several pressure-levels as appropriate apparatus was developed. Diamond does not always form where it is thermodynamically stable; this is what makes diamond synthesis so interesting.

The chemical systems which were studied in connexion with diamond synthesis can be conveniently grouped as follows: (1) direct transition, graphite to diamond; (2) systems involving carbon and oxygen; (3) systems involving carbon as salt-like carbides; (4) miscellaneous chemical reductions, and (5) systems involving carbon dissolved in molten metals.

(1) Direct Transition, Graphite to Diamond

The driving force for this reaction is the increase of density upon going from graphite to diamond. On the other hand, the high heat of vaporization of carbon (more than 100 k.cal./gm. mol.) implies that a high temperature will be necessary before much recrystallization of the carbon occurs. Indeed, the

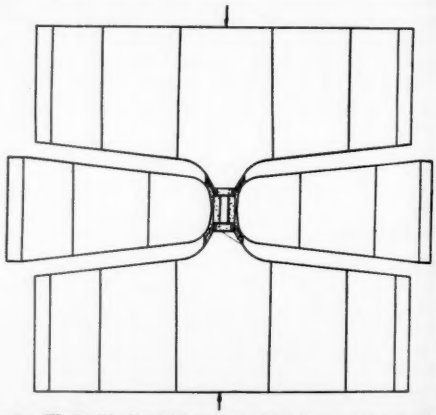

Fig. 2*a*. The 'belt', ultra-high-pressure, high-temperature assembly

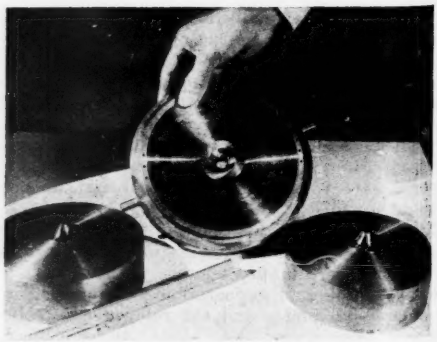

Fig. 2*b*. Photograph of apparatus

* Now at Brigham Young University, Provo, Utah.

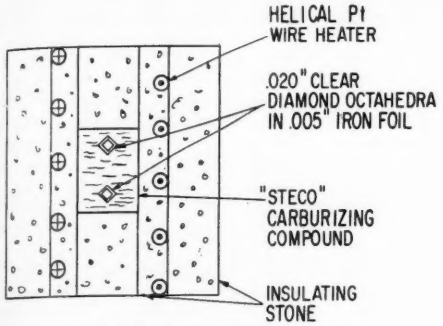

Fig. 2c. Diamond experiment

usual range of temperatures for forming graphite industrially from petroleum coke, pitch, etc., is about 1,800–2,400° C., and some carbons graphitize only slightly at temperatures higher than these.

Some studies made in this laboratory of the graphitization of diamond at 0·1 and 20,000 atm. showed that the graphitization began at 1,500–2,000° C., depending on the particular diamond, and that, in general, higher temperatures were necessary to graphitize diamond at 20,000 atm. than at 0·1 atm. From the change in rate constant with pressure, the volume of the 'activated state' was estimated at about 160 c.c./mol., and the rate of graphitization, in atoms per second, was observed to be 10^5 times the rate of evaporation for the same temperature. This indicated that the diamonds became graphitized by groups of atoms rather than atom-by-atom. For the reverse reactions, graphite to diamond, it would be reasonable to expect a similar reaction mechanism, because the strong intra-sheet binding forces in graphite would tend to make each sheet behave as a unit (as happens in the formation of 'graphite sulphate' or potassium-graphite). Although the coherent sets of sheets of atoms ('crystallites') in graphite or various carbons contain perhaps only 10^4 or 10^5 atoms, the pressure-volume energy of such a crystallite is large compared to kT at only moderate pressures (20,000 atm.). It is known that in some carbons the crystallites are rearranged only reluctantly to form commercial graphite even at 2,700° C. and 1 atm. Thus the effect of increasing pressure is to slow down greatly any recrystallization of solid carbon, and this slowing-down more than offsets the thermodynamic driving force toward diamond gained by increasing the pressure. Experiments in which graphite was heated at high pressure served to squeeze the microscopic voids from the material, so that its density became nearly the theoretical density of graphite, but no diamond was formed, even at 120,000 atm. Perhaps diamond could crystallize from molten carbon at a sufficiently high pressure; but supposing the melting temperature of carbon to be 4,000° C. at this high pressure, one would estimate by an extrapolation that the required pressure would be in the neighbourhood of 200,000 atm. (The increasing incompressibility of graphite with pressure indicates that the required pressure might be even higher than this.) Such an experiment has evidently not yet been performed.

(2) Systems involving Carbon and Oxygen

Such systems are attractive because they are chemically versatile and tend to favour aliphatic rather than aromatic carbon–carbon bonds. The oxide mineral inclusions in natural diamonds[4–6] suggest that perhaps certain oxides could play a part in diamond formation, perhaps through a shift in the carbon monoxide – dioxide equilibrium. In spite of all these attractive features, only graphite or amorphous carbon ever appeared as products from these systems, with one possible exception. This exception was the reduction of lithium carbonate by lithium metal at high pressures. The carbonaceous residue gave a feeble Debye–Scherrer pattern for diamond and scratched glass in a way characteristic of diamond (tiny helical chips were ploughed out of the scratches). A few tiny triangular faces, 1–10μ on edge, could occasionally be seen but not identified. Further experiments did not produce more abundant or larger crystals.

Other systems which were examined included similar reductions of carbonates, oxalates or formates by metals; the decomposition of iron, molybdenum or chromium carbonyls either pure or in solution in stannic chloride or molten salts; the decomposition of sugars and ketones; the electrolysis of molten carbonates; or finally, the attempted solution and transport of elemental carbon in various molten oxides such as borates, silicates, phosphates, 'blue ground', etc.

(3) Systems involving Carbon as Salt-like Carbides

These systems are attractive because they are comparatively rich in carbon, contain carbon atoms as free ions which could easily be built into a diamond lattice after a simple reduction, and are chemically active at low temperatures. However, only the high-pressure decomposition of lithium carbide by the outward diffusion of the lithium ever yielded any potentially diamondiferous product. The material from this decomposition gave a weak Debye–Scherrer diamond pattern, corresponding to a diamond content of about 1 per cent, and also scratched glass to leave the characteristic helical chips.

Other more disappointing reactions included the decomposition $2MgC_2 \rightarrow Mg_2C_3 + C$, the cyanamide reaction $CaC_2 + N_2 \rightarrow CaCN_2 + C$, the electrolysis of calcium or lithium carbides, and the substitution reaction $SiC + Ge \rightarrow SiGe + C$.

(4) Miscellaneous Chemical Reactions

Carbon disulphide is thermodynamically unstable at ordinary pressures and temperatures. At pressures about 45,000 atm. and 400° C. it was found to change into the black solid described by Bridgman[7]. In combination with various metals used as catalysts or reducing agents, carbon disulphide changed into amorphous carbon at higher temperatures and pressures. Similar reductions of chloroform, carbon tetrachloride or cyanides formed amorphous carbon.

Hannay's method was tried, in which lithium, light hydrocarbons and nitrogen-containing substances were heated together at high pressure. Again only amorphous carbons appeared. The simple thermal decompositions of various hydrocarbons yielded similar products, and no diamond.

(5) Systems involving Carbon dissolved in Molten Metals

These systems turned out to be the most fruitful and also, unexpectedly, the most complex.

In our early work, when available pressures were still less than about 50,000 atm., some experiments

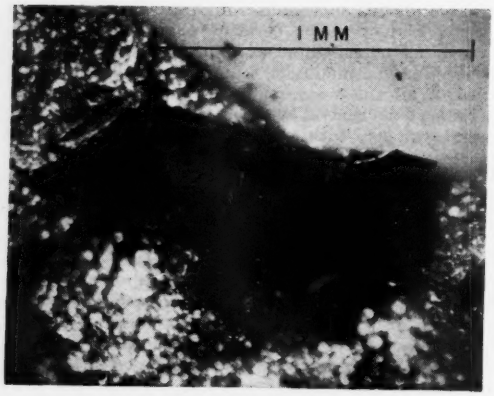

Fig. 3. Diamond in metallic matrix

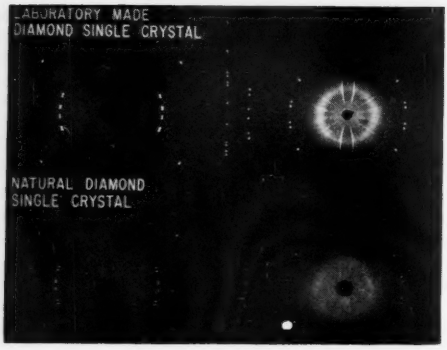

Fig. 4. Debye–Scherrer patterns

were performed with molten aluminium, silver, and even iron. Of course, iron dissolved carbon in appreciable amounts; but the carbon which was precipitated from it was in the form of graphite. No matter how careful the change or how great the fluctuation of temperature, when the pressure was less than 50,000 atm., only graphite resulted. In view of this, it is difficult to see how Moissan's claim to have formed diamond from molten iron–carbon mixtures inside his quenched iron could be sustained, since he could have reached at most only 10,000 atm.[8,9].

A number of experiments were performed using a metallic catalyst and carbonaceous material. One of the first experiments carried out involved heating some seed diamond crystals, iron and a carbonaceous steel-carburizing compound for 16 hr. at about 53,000 atm. and about 1,300° C. (Fig. 2*c*). Out of this there appeared two new diamond fragments with developed crystal faces, each of which was larger than any of the seed crystals. The identification was made by hardness tests and an X-ray diffraction pattern (Figs. 3 and 4). Attempted repetitions of this experiment did not produce diamond. However, it now appears that the iron–carbon system is quite complex at high pressures and temperatures. Several solid phases can form, among them FeC, Fe_3C, graphite and diamond; but which one happens to form depends upon slight variations in temperature, temperature change or chemical composition. Even at 100,000 atm., certain temperature programmes will not permit any diamond to form from iron–carbon mixtures.

Shortly afterwards, a mixture of iron-rich iron sulphide together with carbon and tantalum, as shown in Fig. 5, was heated at about 1,600° C. at about 95,000 atm. The heating time was short, less than 10 min. On the tantalum end disks there formed tantalum carbide, and on top of this lay a black crusty layer of small diamond crystals (Fig. 6). They were identified by their hardness, combustibility and X-ray diffraction pattern. The experiment was successfully repeated many times.

Soon other substances were found to be effective as catalysts for the conversion of carbon into diamond at pressures ranging from 55,000 to 100,000 atm. and temperatures ranging from 1,200 to 2,400° C. They were chromium, manganese, cobalt, nickel, palladium, platinum, etc., or compounds which would react to give the free metals under these conditions, for example, nickel oxide, ferric chloride, etc.

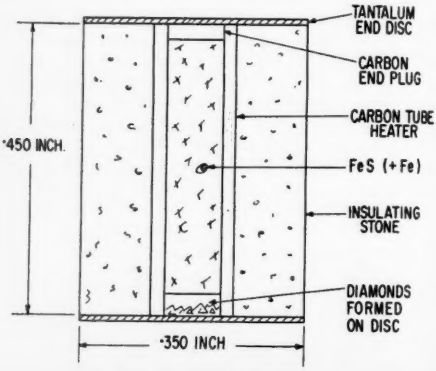

Fig. 5. Diamond experiment

Fig. 6. Cluster of synthesized diamonds

After many experiments it became possible to list some of the conditions peculiar to the formation of diamond.

(1) The pressure and temperature of the system should be those for which diamond is thermodynamically stable.

(2) The temperature must be high enough to ensure that the catalyst metal, saturated with carbon, is molten. Thus the intersection of the melting line of the metal – carbon eutectic with the graphite – diamond equilibrium line sets a lower limit on the temperature and pressure which can be used to form diamond with a particular catalyst. In Fig. 7 the diamond-growing region is shown as a shaded area on the pressure – temperature diagram.

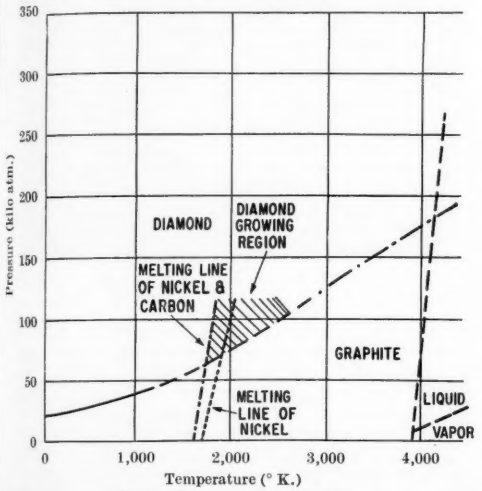

Fig. 7. Diamond-growing region

(3) The catalyst metal can be chromium, manganese, iron, cobalt, nickel, ruthenium, rhodium, palladium, osmium, iridium or platinum. Tantalum is particularly effective for inducing the growth of small diamond crystals, although in some circumstances it may not be as catalytically active as the other metallic catalysts.

(4) New diamond can form whether diamond seed crystals are present or not.

(5) As the synthesis pressure and temperature are moved further into the diamond-stable region away from the graphite–diamond equilibrium line, the rate of nucleation and growth of the diamonds increases and their average crystal-size decreases.

(6) The diamond can grow at very high rates, at least 0·1 mm. per min.

(7) The actual transformation from carbon to diamond occurs across a very thin film, about 0·1 mm. thick, which separates the carbon from the diamond. Thus the transformation is almost 'direct', but the catalyst is essential (Fig. 8). So far it has been found to be very difficult to grow diamond buried in molten catalyst even 1 mm. away from the source of carbon.

(8) Although the main driving force for the formation of diamond is the thermodynamic potential difference between graphite and diamond, temperature gradients can accelerate diamond growth due to the dependence upon temperature of the solubility of carbon in the catalyst.

(9) The kind of carbon used as a starting material has an effect on the kind and number of the diamonds

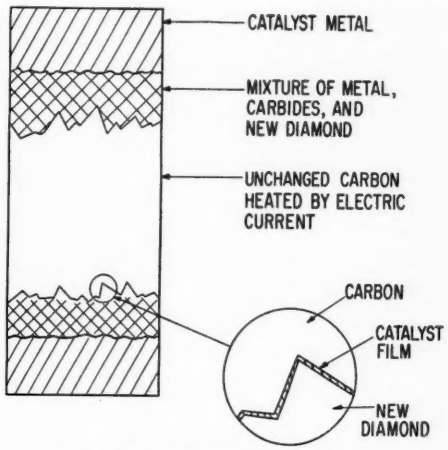

Fig. 8. Diamond growth from graphitic carbon

formed. Good results have been obtained in making diamonds employing ordinary commercial graphite as the starting material. Other carbonaceous material may be employed as the source of carbon, such as carbon black or a sugar charcoal; but graphite is preferred.

(10) Sometimes graphite forms from a carbon-rich melt, particularly when the melt freezes, even though the pressure and temperature are appropriate for diamond stability. Diamond may or may not form at the same time. Apparently the formation of diamond is not a simple process.

(11) The diamonds easily include or grow around foreign particles present in the mixture, particularly at high rates of growth. Often some of the catalyst metal will be thus trapped in a diamond crystal.

(12) The diamond crystal habit varies according to the temperature of formation. Cubes predominate

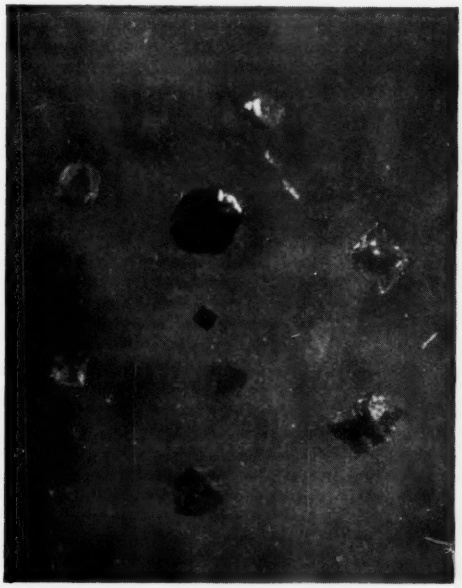

Fig. 9

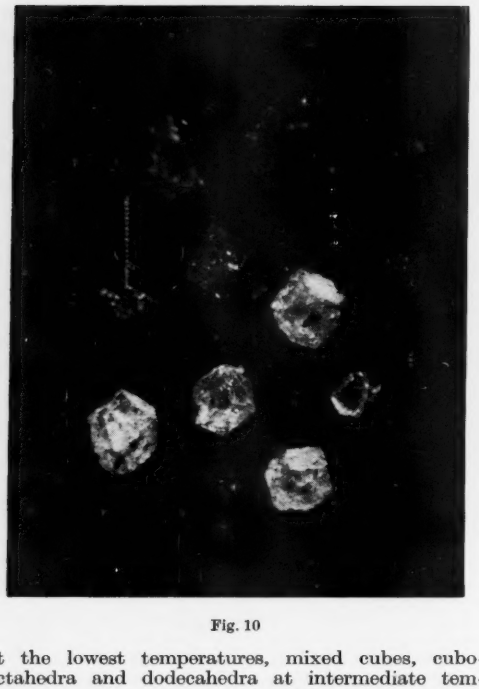

Fig. 10

Fig. 11

at the lowest temperatures, mixed cubes, cubo-octahedra and dodecahedra at intermediate temperatures, and octahedra at the highest temperatures. No tetrahedra have been found. At high growth-rates, octahedra are frequently twinned through an octahedral face as a mirror plane. Growth terraces or steps are common on the diamond crystals, but no growth spirals have been found so far. The colour varies from black at low temperatures through dark green, light green and yellow, to white at the highest temperatures. In many cases, the colour does not depend on the particular catalyst used but on the operating temperature relative to the melting point of the catalyst–carbon mixture. Green and yellow colours seem to be associated with imperfections in the diamond crystal lattice rather than with the presence of a specific impurity. Many of the physical characteristics of natural diamonds have been duplicated in the laboratory[10].

Some photomicrographs of various synthetic diamond crystals are shown in Figs. 9–11.

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FASCICULUS LIMPIDUS NOV. GEN., NOV. SPEC., A REPRESENTATIVE OF A NEW GROUP OF BACTERIA

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A PECULIAR organism, the nature of which puzzled me much at first, was observed in putrefaction cultures inoculated with a small quantity of soil from a dried-up pool not far from Cape Town, South Africa. It contained fragments of twigs and rock along with powdery earth. This soil sample had been very kindly sent to me by Dr. M. A. Pocock, Rhodes University College, Grahamstown, with the idea that it contained colonial Volvocaceae. This was the case: *Volvulina*, a mixothrophic member of the Volvocaceae, together with species of *Chlorogonium*, *Coccomonas* (or *Dimorphococcus*), an undescribed species of *Lobomonas*, an interesting species of the Polytomeae, and others turned up under suitable conditions.

Successful cultures were prepared in the following way: a quarter of a dry pea was put on the bottom of a test-tube, covered with clay soil and water and heated in a steam chamber for 1 hr. on two consecutive days. The following morning, or later, inoculation was done with a small amount of the original soil.

The culture was kept in the light. Other mixtures, such as grains of barley, bits of cheese, a little starch,

different kinds of soil instead of clay soil, did not produce the same interesting type of biological community, but only a much more scanty growth without Volvocaceae and the new organism here described.

The original soil, even in much greater quantity, with water or a dilute mineral nutritive solution and trace elements, was still less productive. This is noteworthy, because it is of general application. It shows that the soil sample no longer contained enough of the substances which had originally produced the mixed population, the resting stages of which regained vitality in the tubes prepared as described. It also indicates that heating of the clay soil is necessary for these organisms to find suitable conditions for growth.

In all other instances the various organisms appearing in such putrefaction cultures could be maintained indefinitely by inoculating them into identical tubes without the original soil, in series. Not so the new organism, which also failed to multiply in a considerable number of media with various organic substances usually suitable for the nutrition of colourless flagellates, bacteria, etc. After repeated washing of the new organism before inoculation, such tubes remained clear and sterile.

In the original culture tubes the peculiar organism in question was observed in considerable quantity near the surface of the soil-mud. The experiment was successfully repeated several times with the same and similar soil samples from the Cape Flats, but only when light was admitted did the new organism appear. It consisted of translucent, almost spindle-shaped structures tapering at both ends when inspected with low magnification inside the culture tubes. Later, the new organism swarmed in the higher regions, too, but the water never really teemed with them, and the other organisms mentioned above were always present.

For closer investigation, specimens of the organism were picked up with the capillary pipette and inspected in hanging drops or in mounted preparations. What was mistaken for colourless, finely striated flagellates at low magnification was at high power seen to be composed of long filaments, some of them bent and twisted to form colonial bundles. These were broadly spindle-shaped, often somewhat flattened, with both poles tapering but not strictly pointed (Figs. 2–5). The individual filaments arranged more or less parallel to one another, though converging, did not all terminate at the same point. Under pressure of the cover-slip they tended to spread, the filaments separating (Fig. 11). Indian ink penetrated between the units of the colony. There is, therefore, no gelatinous matter surrounding the whole or glueing the filaments together. They are united in bundles (*fasciculus*) and have a translucent, limpid appearance. The organism will therefore be called *Fasciculus limpidus*.

In suitable conditions the colonies moved along their axes, rotating as flagellates generally do. They did not glide along solid surfaces but swam freely through the water, though more slowly than infusoria or even the majority of flagellates usually do.

The motile colonies may aggregate chemotactically. This became apparent when a quantity of culture fluid in a watch glass was inspected for a longer period. Various motile organisms, such as *Spirilla*, small infusoria and *Coccomonas*-cells, assembled around debris particles, were followed by the colonies of our organism, most of which aggregated after some time at certain points. In such open watch glasses, contained in a Petri dish, *Fasciculus*, poured from a test-tube culture, together with other members of the community, kept only for a few hours and could not be identified the following morning, while *Volvulinopsis* and the others kept moving for a whole week. A probable inference is that *Fasciculus* is micro-aerophil, an idea strengthened by our experience and observations with cultures.

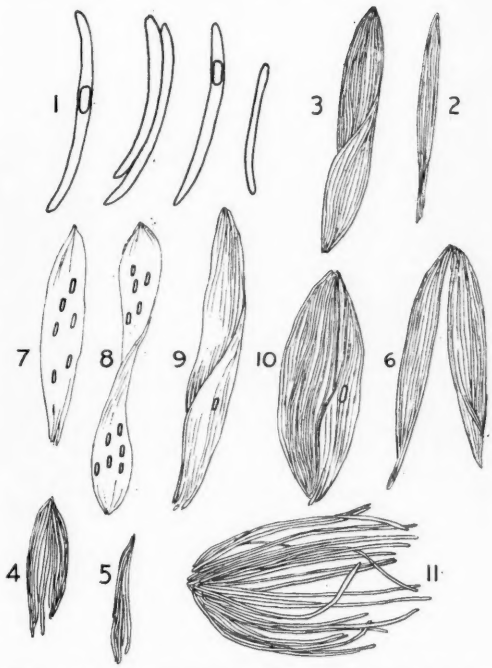

Fig. 1. Individual components of colony mechanically isolated, two of them with spores. 2, Small, narrow colony. 3, Large, twisted colony. 4 and 5, Small, frayed colonies. 6, Rare instance of longitudinally split colony. 7–10, Colonies with spores: 7, colony of the most frequent types—during spore formation, the outlines of the filamentous components have become invisible to a great extent; 8, colony with narrow waist and spore formation; 9 and 10, more or less twisted colonies, each with one spore. 11. Normal colony with filaments separated by pressure on cover-slip. (Fig. 1, × 1,000; others, × 500)

The shape and appearance of the colonies varied (Figs. 2, 4, 5). Apart from the large closely-knit spindles with only slightly frayed ends, there were smaller and narrower ones, and occasionally, though rarely, slightly bent, slender rods which, judging by their optical appearance, belonged to the same organism. Sometimes two narrow spindles cohering at one pole were seen (Fig. 6). Larger, presumably older, colonies had a constriction in the middle, and the filaments were twisted (Figs. 3, 8). The waist is believed to indicate an imminent partition of the colony.

Cells shorter than the total length of the colonies, and others which divided like bacteria, could often be observed. There is little doubt that the units divide after reaching a certain length, and that the daughter cells glide along one another to increase the width of the colonial bundles. I did not, however, find any signs of individual filaments breaking loose from the colonies and starting new ones.

The main mode of reproduction is by spore formation. In older cultures, colonies were found which

were more limpid than young ones. Only their outlines were readily observable, while the inner parts of the spindle were optically almost empty except for small cylindrical bodies which by their high refractability, particularly in dark-ground illumination, revealed their nature as bacterial spores (Figs. 7, 8). This was confirmed by their capacity for retaining the fuchsin stain on treatment with acid alcohol.

Later on, transition stages in spore formation were also found in colonies in which the filamentous cell-units were still readily visible. Not all of these formed spores. The spores were usually close to the middle. Their shapes varied from almost oval to, more commonly, cylindrical. Their width was about 1·5μ, their length 5–7μ.

These spores are no doubt the reproductive units responsible for the development of *Fasciculus* from completely dry soil. Their germination could, unfortunately, not be observed because of the failure to cultivate the organism and to separate it from other organisms. It is very peculiar that the individual cell margins vanish almost completely during spore formation, although the whole colony continues to swim about, and its outlines remain clearly visible (Figs. 7, 8).

The structure or nature of the filaments composing the large spindles is also different from that of most bacteria. As already mentioned, optically the organism is fainter than other organisms. In dark-ground illumination it becomes more distinct, and the outlines of the filaments show more clearly than, for example, the outer membranes of Myxobacteria.

These filaments are believed to be cells. They are 2μ across and about 50–100μ in length. They stain with fuchsin and methylene blue, but, in accordance with their low refractability, not strongly. They do not keep the Gram stain, contrary to most bacterial spore-formers. Only the membranes of the spores were stained; they were also more deeply coloured when treated with the Ziehl-Neelsen technique.

The mode of locomotion, rotating and swimming freely through the water, recalled that of flagellates or large bacteria. I did not succeed in demonstrating flagella with the help of Loeffler's technique, Deflandre's nigrosin method, or dark-ground illumination. Quick drying on fat-free cover-slips or fixing with osmium tetroxide vapour or iodine or Schaudinn's mercury chloride fixation did not make any difference. But I believe this failure was somehow due to inadequate technique, and do not doubt that flagella do exist, since the impression of the swimming movement scarcely allows of any other interpretation.

If this were so, we would have another example of an 'organized' bacterial colony as earlier described for *Vannielia aggregata*[1]. This belongs to the Athiorhodaceae, a family where colony formation had not been known to exist. There, also, many cells are aggregated to constitute a composite unit driven through the water and rotating by co-operation of the flagella; but here the similarity ends. While in *Fasciculus* the units of the colony are long, tube-like structures, those of *Vannielia* are rod-shaped cells radiating from the centre of the colony. Another motile bacterial colony is that of *Chlorochromatium aggregatum*, where again the arrangement of the individual components is quite different. Only one relatively large, central rod possesses a flagellum responsible for the movement of the colony, while the yellowish green small outer cells only adhere to the actively swimming central rod.

It is not possible to include *Fasciculus* in one of the taxonomic groups of the Bacteria. Very long tubiform cells are known in *Lineola*[2], but this genus does not form colonies, and the production of spores and the appearance of the cells are different. In *Lineola* droplets and other contents are visible under the microscope, and the staining with various dyes is quite normal for a bacterium. *Fasciculus* is much less stainable and the inner part of the cell is almost empty optically. Moreover, the ecological conditions in which the new organism thrives seem to be peculiar. A better insight into its nature could only be obtained by cultivation. I will gladly supply portions of dry soil to bacteriologists who are interested in this creature.

[1] Pringsheim, E. G., *J. Gen. Microbiol.*, **13**, 285 (1955).
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BIOLOGICAL PROBLEMS ARISING FROM THE CONTROL OF PESTS AND DISEASES

THE Institute of Biology has developed a technique for cutting through the hedges which grow up between fields of knowledge as biology undergoes speciation into ever new branches. One of the methods of doing this used by the Institute is to arrange symposia for which the subjects and speakers are chosen with considerable care. Thus, before even a word was spoken in the Royal Geographical Society's well-filled lecture hall on October 1, a look around indicated a successful meeting, for there were many well-known specialists in different fields who seldom previously have found themselves sitting in one room. The subject of this two-day symposium, namely, "Biological Problems arising from the Control of Pests and Diseases", is one of wide and topical interest. The speakers, including those who contributed to several stimulating discussions, were economic entomologists and botanists, medical men and veterinarians, psychologists and humanitarians, in addition to academic biologists.

The symposium was arranged in four sessions, each under a different chairman. This arrangement divided the subject rather broadly into problems associated with arable agriculture, animal husbandry, human disease and health, but the matter presented tended to transcend any grouping. It became apparent that there are many connecting threads between, for example, the drug resistance developed by bacteria and the stimulation to growth of animals consequent on small additions of antibiotics to their diet, that the consequences of malaria control react quickly on the ecological problems of crop and animal pests through changes in human needs, and that too rigid a control of mental deficiency might have a retarding influence on science and art. Several facets of the discussion pointed to the human being

as the greatest pest of all. One speaker was bold enough to suggest that every pest and disease worthy of the name was, in fact, a human artefact, and given time he might convert almost every surviving wild organism into a pest. Although some would scarcely go so far, there were several expressions on the value of maintaining at least some areas of the world in a natural or semi-natural state. Thus, in the problem of controlling agricultural pests, reference was made to Elton's plea for ecological diversity if only to provide reservoirs of the predators and parasites of pests.

The stage was set by Mr. F. C. Bawden, chairman of the first session, who directed attention to the unexpected and sometimes undesirable results which follow action against any particular pest or disease of importance in agriculture. The control of one may let in another. He was unable, however, to quote any case where the secondary trouble had resulted in greater economic loss than the primary one, and therefore concluded that on the whole there was always a net gain. This theme was taken up by Mr. A. H. Strickland, of the Ministry of Agriculture and Fisheries Plant Pathology Laboratory at Harpenden. He provided a valuable assessment of recent work with insecticides, but neglected the classical work of biological control because it was well covered in a recent survey by Prof. G. C. Varley in a paper before the Royal Society of Arts. He instanced cases where eradication of species had been attempted, such as the Colorado beetle from Europe and the Mediterranean fruit fly, which has twice been introduced into and eradicated from the United States; and he pointed out that in Britain no less than a fifth of the acreage of root and some vegetable crops is treated annually with insecticides as a routine measure. To those—including many farmers—who deplore the very widescale use of insecticides and herbicides as an excuse for sloppy husbandry, Mr. Strickland had some encouraging words about recent studies of the manipulative possibilities such as physical control of the soil by rotovation, and the adjustment of spacing in sowing and planting which can render crops unattractive to pests or stimulate the crop to grow away.

Dr. T. J. Martin, of the Research Station, Long Ashton, dealt with the direct risks to man arising from the fact that fifteen out of the forty-two or so insecticides and fungicides in common usage are in the highly toxic category. Study of the risks to spray operators led to the Agriculture (Poisonous Substances) Regulations of 1956, and, in spite of some accidents, it seems that the risks to the consumers of crops which have been subjected to a variety of toxic sprays are under control, at least in Great Britain. Discussion revealed that, with the exception of arsenic, for which there is a legal tolerance, the use of any spray on the land in Britain is entirely at the discretion of the manufacturer and the farmer. Neither Dr. Martin nor any other speaker was in a position to deal with the influence of toxic materials on wild plants and animals or on game, although these largely unknown but important influences were doubtless in mind. It is abundantly clear that there is to-day a heavy responsibility falling on entomologists and botanists to obtain and interpret information on the selectivity and tolerance-levels of these chemicals, in order to give advice to manufacturers and users on formulations, dosages and methods of application in such a way that indiscriminate slaughter can itself be brought under control.

Mr. F. G. H. Lupton, of the Plant Breeding Institute at Cambridge, set a different note by describing some striking successes in controlling diseases through genetical resistance or tolerance; but he mentioned that all too often the plant breeder is called in only when other methods have failed. Among other examples he described the ding-dong race which was started in 1912 by Sir Roland Biffen and is still in full cry between the genes of newly evolving races of the rust fungus and resistant genes of wheat sorted out by plant breeders. The series Marquis – Ceres – Thatcher – Pilot – Selkirk have so far kept alive the economy of the Great Plains, but the race is still neck-and-neck.

The second session introduced several problems from overseas. Thus, Mr. M. Crawford, of the Commonwealth Bureau of Animal Health at Weybridge, emphasized that eradication of a killing disease of livestock, such as rinderpest, could lead to harmful effects from over-population, over-grazing and malnutrition if achieved among peoples who regard stock as a social or religious asset without economic controls. Such experience was referred to also by Mr. W. H. Potts, formerly of the Colonial Service, with reference to the control of tsetse flies and trypanosomiasis. He was not, however, prepared to support the tendency in recent years to hail the tsetse fly as the preserver of the African soil from destruction by man. This theme, like the earlier one on controlling agricultural pests, led to discussion on the advantages or disadvantages of ecological diversity as a background for the economic use of land. There is, for example, evidence that in the African semi-arid bush the broad spectrum of wild indigenous fauna, fully adapted to living off the indigenous vegetation at all levels, could, under proper systems of management and annual cropping, produce human food little if any less than is produced by the narrow spectrum of exotic domestic stock. At least there is a case for spending money to explore such possibilities in selected areas, rather than to spend all that is available on the blind eradication of wild-life and tsetse flies.

The control of human diseases in tropical areas was the subject of two contributions, by Prof. T. Davey, of the School of Tropical Medicine at Liverpool, and Sir Gordon Covell. The latter mentioned that during the World Health Organization campaign there were two hundred teams working in India, each of which looked after one million people. Despite such campaigns, the Organization's figures show that the annual loss from malaria is still a vast one. The improvement of physique and of work undertaken by persons in malarial areas is marked, following control. There is normally some resistance to malaria, but this resistance is only local, so that an influx of persons from another district may result in severe outbreaks. Although Sir Gordon did not say so, this, of course, was known in England during past centuries, when it was noted that a wife from outside taken into such malarial areas as the Fens or Hundred of Hoo was liable to die within a short time, whereas the locals were in balance with their disease.

Prof. Davey dealt more with the sociological problems expected as a result of the control of such diseases as malaria, and pointed out that nowadays in India the excess of births over deaths is some 15,000 a day. In discussing birth control as the biological remedy, he mentioned that certain classes are more amenable to birth-control methods than others, and that in a low-level subsistence type of

society every additional member of the family gives another worker, and so a better chance for survival. Where social conditions are better, each additional mouth is a liability rather than an asset. Thus the lower the subsistence-level the greater the birth-rate tends to be.

Dr. E. Slater, of the National Hospital for Nervous Diseases, raised some interesting points about the genetics of mental disease, and pointed out that the discovery of new methods of treatment enabled certain diseases which are transmitted genetically as dominants to increase their proportion in the population. This was simply done by overcoming the biological disadvantages which these dominant genes will contain, provided no treatment is given. Among the interesting points he made were that the manic-depressive type of patient is met with ten times as frequently among scientists as among the rest of the population. This may be a question of either cause or effect. Schizophrenics are found particularly among artists, and in these patients fertility is only 70 per cent that of normal. There is a possibility that this disease may be associated with some genetic advantage. The question whether certain types of mental defective should be sterilized is difficult because it is possible that workers in, for example, the artistic and scientific fields, may show improved output over the normal if they have some minor degree of mental disease.

The problems which arise from drug-resistance in bacteria were treated in a sparkling contribution by Dr. Mary Barber, of the Postgraduate Medical School, London. She pointed out that not all bacteria have taken the massive attack by antibiotics in clinical medicine lying down; in the case of *Staphylococcus diogenes*, drug-resistant strains are now the major bacterial scourge in hospitals all over the world. Resistant strains of bacteria may be drug-tolerant or drug-destroying, and in certain cases may even become drug-dependent. Evidence points to the resistance being genetic rather than adaptive, and that penicillin, for example, has caused a prodigious evolution in the population structure of *Staphylococcus* by simple selection. Those strains carrying resistant genes which formerly were present in a tiny proportion have now increased to 60 or 70 per cent of the population in most hospitals. The same principle applies in the case of insect resistance to the new synthetic insecticides, as explained by Dr. J. R. Busvine, of the London School of Hygiene and Tropical Medicine. In more than a hundred harmful insects resistant strains have occurred, and in some cases the inheritance of the resistant trait has been shown to be of a normal Mendelian type. Whether the trait is 'physiological', which is immune to the poison, or 'behaviouristic', which manages to avoid it, its emergence seems to constitute greatly accelerated evolution on essentially Darwinian lines. Dr. R. Brande, from the National Institute for Research in Dairying at Shinfield, spoke on the recent experiments which show that very small amounts of antibiotics added to the diet of domestic animals increase growth-rate up to 10 per cent and the efficiency of food conversion by from 3 to 5 per cent. He explained that economic advantage of this phenomenon is being taken now on quite a large scale in the United States, although the biological reasons for it are as yet in the realm of conjecture.

The last contribution to the symposium was by Dr. G. C. L. Bertram, from St. John's College, Cambridge, who spoke of 'ethical' or deliberate selection in mankind as having supplanted natural selection. He sketched the sequence of events which led to a doubling of the human population in the past eighty years or so, and the probability that it will double again during the next forty years—European dominance, followed by reduction of strife, the development of hygiene, and the control of biological competitors. Human compassion has led to death control, and now is the time for a great extension of birth control as a further expression of the freedom of choice by the individual. Having accepted Sir James Gray's concluding thought expressed in his presidential address at the York meeting of the British Association that man now has the intelligence and the knowledge to control his own destiny, the question has still to be answered what that destiny is. In a cynical moment, Dr. Bertram compared modern man with a drunkard riding a runaway horse, whereas Dr. A. S. Parkes, who guided this final session from the chair, expressed the hope that our freedom of choice would never become so wide that we would ourselves have to decide whether or not to be born.

E. B. WORTHINGTON

DARWIN'S ILLNESS

By PROF. S. ADLER, O.B.E., F.R.S.
Department of Parasitology, Hebrew University, Jerusalem

DARWIN'S illness, which practically amounted to forty years of invalidism, has given rise to considerable speculation. The doctors who treated him could find no physical explanation for his distressing symptoms and apparently concluded that he was a hypochondriac.

Darwin, whose sufferings were very real, complained in a letter to Hooker "many of my friends I believe think me a hypochondriac". Commenting on this, the late Sir Arthur Keith[1], in his book "Darwin Revealed", remarks emphatically "Darwin *was* a hypochondriac, a very real one . . .".

Hubble[2] states that "it is apparent that his illness bears the unmistakeable marks of an emotional disorder" and adds, "his psychoneurosis may be regarded as an adaptation to his environment which nourished and protected in the highest degree his uncommon genius". This author[3] justifies his diagnosis on the basis of Darwin's family history. He rightly points out that Darwin's wife was an exceptionally devoted nurse and his son showed a tendency to hypochondria. It may, on the other hand, be argued that the above qualities were acquired and not inherent; chronic invalidism in the head of a family, whatever its cause, has psychological consequences and may well induce in the mother a strong tendency to nurse and protect, and in the younger members of the family an exaggerated fear of disease.

Good[4] invokes psycho-analysis and considers the whole of Darwin's symptoms as a reaction to his father's autocratic personality. He goes so far as to say, "Darwin's punishment for the unconscious patricide was a heavy one—almost forty years of severe and crippling neurotic suffering which left him at his best fit for three hours' daily work".

Keith accepts the unconscious as responsible for all Darwin's symptoms. "In Darwin's case the voluntary part of his brain seems to have too easy and too free an access to his involuntary part. Therein I believe lies the source of all his ills." Nevertheless, in referring to one episode of 1873 he writes, "I infer this to be an attack of true angina of the heart".

A purely psychological aetiology for Darwin's illness cannot be accepted as conclusive until all other factors have been eliminated. Gaylord Simpson[5] has recently suggested that Darwin suffered from brucellosis. There is no direct evidence to refute or prove this theory.

It is obvious that all attempts to explain Darwin's symptoms must be based on a detailed analysis of the events recorded in the voyage of H.M.S. *Beagle*, because there is nothing of any medical significance prior to the voyage which could throw light on his subsequent illness. As Lady Barlow[6] rightly remarks, "Charles Darwin's forty years of invalid existence moreover were an unexpected sequel to his youthful vigour, for his strength and endurance were well above the average, as Captain Fitzroy has recorded in his account of the various incidents during the *Beagle* voyage".

Darwin was a dedicated geologist and throughout his whole life maintained the keenest interest in this subject. Nevertheless, at the age of thirty-three, he was compelled to abandon field work in a favourite subject because he found by experience that the physical effort it entailed exhausted him. Is it reasonable to ascribe this sacrifice to a belated reaction to a domineering father ?

There is one very important point in Darwin's case-history which writers on the subject have apparently overlooked.

In "The Journal of the Voyage of H.M.S. *Beagle*", Chapter 15, Darwin (March 25, 1835) writes : "We slept in the village of Luxan which is a small place surrounded by gardens and forms the most southern cultivated district in the province of Mendoza ; it is five leagues south of the capital. At night I experienced an attack (for it deserves no less name) of the Benchuca a species of Reduvius, the great black bug of the Pampas. It is most disgusting to feel soft wingless insects about one inch long crawling over one's body. Before sucking they are quite thin but afterwards they become round and bloated with blood, and in this state they are easily crushed . . .". Darwin observed 'Benchucas' for at least four months and he fed one specimen on a ship's officer. "This one feed for which the Benchuca was indebted to one of the officers kept it fat during four whole months ; but after the first fortnight it was quite ready to have another meal."

The "great black bug of the Pampas" which attacked Darwin in Luxan can be no other than *Triatoma infestans*, which has become adapted to human habitations and feeds on man and domestic animals throughout extensive regions in South America. It is the most important vector of *Trypanosoma cruzi*, the causative agent of Chagas's disease, in the Argentine, Chile and parts of Brazil. The province of Mendoza has a relatively high incidence of Chagas's disease, and according to South American colleagues with whom I discussed this problem at the recent congress on Chagas's disease held in Rio de Janeiro during July 5–12 [see p. 1114 of this issue of *Nature*], as many as 60 per cent of the population in parts of Mendoza give a positive complement-fixation test for *T. cruzi* and as many as 70 per cent of specimens of *Triatoma infestans* are infected with the trypanosome. Darwin was therefore definitely exposed to infection on at least one occasion. It is highly probable that he was also exposed on other occasions, but he particularly noted the incident in Luxan because of the intensity of the attack of Benchucas ; parts of Chile through which he passed show a 10 per cent positive complement-fixation test in the population together with a considerable infestation with infected *Triatoma infestans*. We must also bear in mind that Chagas's disease has a very wide distribution in South America from Chile to Mexico (recently a few cases have been recorded in Texas) and the province of Mendoza is an area of relatively high infestation.

The incident in Luxan cannot, however, explain Darwin's previous seven weeks severe illness during September and October 1834 which confined him to bed in Valparaiso and commenced during the last week of a six weeks journey. Unfortunately, no clinical details of this episode are available. Keith writes, "As to the nature of this illness I do not know of any exact information but typhoid fever is a very probable diagnosis". There is not the slightest suggestion of an emotional cause for this incident.

The complications and sequelæ of Chagas's disease have been studied in detail by some of the ablest South American pathologists and clinicians, particularly in Brazil, the Argentine, Chile and Uruguay, and considerable literature on this subject is now available. Particular attention has been paid to the clinical and pathological aspects of the myocarditis which appears in some victims of the disease. Darwin's exhaustion after physical effort can well be explained on the basis of an infection with *T. cruzi*.

At the above-mentioned congress a number of Brazilian pathologists and clinicians maintained that apart from, and in some cases in the absence of, cardiac complications, Chagas's disease may be associated with clinical signs related to the alimentary tract, particularly the œsophagus, colon and stomach, as a result of damage to Auerbach's plexus. They based their conclusion on the high incidence of positive complement-fixation tests in patients with symptoms related to these organs. There was no unanimity on this point because although many such cases have been found in Brazil, few or none have as yet been recorded from the Argentine.

It is obviously impossible to *prove* that Darwin was a victim of Chagas's disease but two points cannot be overlooked : (1) his symptoms can be fitted into the framework of Chagas's disease at least as well as into any psychogenic theory for their origin ; (2) it is possible to pin-point with certainty a definite incident on March 25, 1834, during which he was exposed to optimal conditions for infection with *T. cruzi*.

[1] Keith, A., "Darwin Revealed" (Watts and Co., London, 1955).
[2] Hubble, D., *Lancet*, **244**, 129 (1943).
[3] Hubble, D., *Lancet*, **265**, 1351 (1953).
[4] Good, R., *Lancet*, **266**, 106 (1954).
[5] Gaylord Simpson, G., *Sci. Amer.*, **199**, No. 2, 117 (August 1958).
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OBITUARIES

Mr. J. T. Davey and Mr. H. J. Morris

In the air disaster at Bordeaux on September 24, the International African Migratory Locust Organization, which exists to prevent the escape of swarms of the Migratory locust from the recognized outbreak area in the flood plains of the Niger, south-west of Timbuktu, suffered a very severe blow. The fifty-three people killed included no less than eight associated with that Organization: Mr. J. T. Davey, aged thirty-six, director of research; Mr. H. J. Morris, aged thirty-six, an experienced scientist newly appointed as an assistant to Mr. Davey, and his wife; Madame Duhart, wife of Monsieur A. J. Duhart, director of survey and control, and one of their children; and Monsieur J. J. Rey, one of the locust control officers, and his wife and child.

James Thomas Davey graduated from the University of Bristol and then took a diploma in agriculture at Cambridge and spent a year at the Imperial College of Tropical Agriculture in Trinidad. He first went to Africa in 1947 as an entomologist in the Department of Agriculture in Nigeria, where he investigated the habits and ecology of certain species of biting flies (tabanids and tsetse flies). At the same time, he became interested in locusts, and in 1948 he embarked on a detailed ecological study of the African Migratory locust, partly in association with H. B. Johnston. Particular attention was paid in this study to the neighbourhood of Lake Chad, which was under suspicion as a possible outbreak area, and the important conclusion was reached that while the Migratory locust does occasionally swarm there, the Chad area is not comparable as a source of swarms with the recognized outbreak area in what was then the French Sudan.

With this valuable experience behind him, he accepted in 1951 an invitation from the International African Migratory Locust Organization to visit the outbreak area on the Niger in order to extend investigations already begun by others of the ecology and seasonal movements of the locust there. His secondment to that Organization by the Government of Nigeria for this purpose was extended in 1952 for two years. An outcome of this mission was a decision by the Council of the Organization to establish a permanent Research Service. Davey became director of it, and he continued in that capacity until the time of his death. Through his own ability and personal qualities, including a very thorough practical knowledge of French acquired mainly by usage, the Research Service and its scientific work became integrated into the Organization in a highly successful manner, which could not have been achieved without the respect, affection and support which he won from all his colleagues.

His scientific work consisted mainly of studies of the seasonal movements of the locust population in and around the Niger plains in relation to the seasonal rainfall, river-level and flooding of the plains by overflow from the river. By means of an impressive programme of field-work which involved the marking of more than a million locusts individually with paints, during a period of four years, and releasing them in particular localities in and outside the plains in the hope of recapturing some of them elsewhere, he succeeded in demonstrating a regular seasonal shift of population (already suspected by G. Remaudière, who conducted an ecological study of the locust in the flood plains during 1949–50) between the plains and the surrounding arid country. His work further indicated that certain parts of the plains are far more important than others as breeding grounds of the locust. A much better understanding of the outbreak area as such has resulted from these investigations, and this has led to important improvements and economies in the supervision and preventive control of the locust.

Davey travelled widely in Africa in the course of his duties. In 1953 he visited the outbreak areas of the Red locust in Northern Rhodesia and Tanganyika and toured parts of the vast area of eastern Africa over which the Desert Locust Survey, which has its headquarters in Nairobi, operates. Recently, he went to the Sudan Republic to see and discuss with the authorities there the circumstances in which a local increase in the population of the Migratory locust had occurred. His interests were wide and he was a good companion on journeys in remote places. His zest for life and his vigour and resourcefulness enabled him to take in his stride the many difficulties, some of them severe, which arise in 'bush travel' in Africa. The wild life of Africa appealed to him greatly. He knew the mammals of his areas well and was a keen shot, but he never shot animals solely for the sake of shooting. In connexion with his work, he made extensive collections of grasshoppers and plants, and these have added considerably to knowledge of the acridid fauna and the flora of the Niger flood plains and the surrounding country.

Fortunately, he made a point of writing accounts of his work at frequent intervals, and very little of the work that he had completed will be lost. His most important publications are two long papers on the ecology of the Migratory locust in what he called the Central Niger Delta; these form part of a planned series of three, and it is understood that the third part was virtually complete in typescript when he died. It is fitting that this valuable series of papers is being published in *Locusta*, the journal of the international organization which he served so well.

The death of 'Jimmy' Davey, while still young, removes a man who was confidently expected to play an important part in the field of locust research and control in the future. His wife survives him, with three young children.

Hilary Jolliffe Morris graduated from St. John's College, Oxford, in 1948. A few years later he joined the Research Division of the Ministry of Agriculture of the Sudan, where he undertook pioneer studies of techniques of control of the Desert locust. This work, which covered a period of five years, contributed significantly to the development of aircraft-spraying and of low-volume ground-spraying against locusts, and in the course of it he became familiar with methods for the field-assessment of spray deposits and of the results of spraying operations.

In 1957 he joined the Colonial Pesticides Research Unit at Porton Down, near Salisbury, England, where

he was occupied for two years in laboratory work on the toxicity of new insecticides to mosquitoes. He was essentially a field-man, however, with a strong liking for Africa and a desire to resume locust research, and when a suitable opening occurred in the Research Service of the International African Migratory Locust Organization he applied for the post and was selected.

This new appointment was for an investigation of the applicability of modern methods of locust control, particularly spraying from aircraft, in the conditions of the outbreak area of the Migratory locust on the Niger. Morris was very well fitted by his accumulated experience and personal qualities for this important task, and he set out with high hopes and keen interest on the journey which was to have taken him to the sort of work that he liked best and considered worth while because of its benefit to Africa.

Mr. and Mrs. Morris had been married only six months when they died. T. H. C. TAYLOR

NEWS and VIEWS

Scientific Adviser to the Ministry of Defence: Sir Frederick Brundrett, K.C.B., K.B.E.

IT has been announced that Sir Frederick Brundrett will be retiring at the end of the year from his post of scientific adviser to the Ministry of Defence, and chairman of the Defence Research Policy Committee, shortly after his sixty-fifth birthday. Sir Frederick has had a life-time's association with the scientific aspects of defence, initially within the Admiralty, and for the past ten years of his career dealing with defence science in all its aspects. A member of the R.N.V.R. in the First World War, he joined the scientific staff of the Admiralty in 1919 and remained at H.M. Signal School, Portsmouth, until 1937, when he moved to headquarters. His remarkable qualities as a scientific administrator and his perception of scientific ability were given full scope during the Second World War, when he made a major contribution to the selection and allotment of scientists to the several departments needing them. Since the War his talents for organization have been given full rein at the Admiralty and elsewhere, but his greatest contribution has undoubtedly been in the clarification and stabilization of defence research and development policy as a whole over the past few years. His contributions to the rationalization of the research and development programme so as to harmonize the needs of the Services with the national resources have been markedly successful, and a great debt is owed to him for his work in this field. What he has accomplished is due to three qualities which he has in abundance: a real understanding of Service needs and Service modes of thought, a basic understanding of scientific practices and requirements, and a capacity for hard, thorough and clear-headed work equalled by few and probably excelled by none. A distinguished player of games when younger, and an extremely successful scientific agriculturist to-day, it is to be hoped that his advice and his services to the Scientific Civil Service will not wholly end with his departure from the Ministry of Defence.

Sir Solly Zuckerman, C.B., F.R.S.

SIR SOLLY ZUCKERMAN, who is to succeed Sir Frederick Brundrett as scientific adviser to the Ministry of Defence, is no stranger to either defence or to Whitehall. Sir Solly was born in South Africa in 1904; he came to Britain in 1925 and rapidly became known as a distinguished research anatomist. He at present holds the Sands Cox chair of anatomy in the University of Birmingham, and he is especially well known for his work on the primates. During the Second World War his wide scientific talents were drawn on freely by many branches of the Services, but he was perhaps most closely associated with the Royal Air Force, and he made important contributions to the operational analysis of the effects of bombardment, particularly from the air. In the past decade he has combined his work at the University of Birmingham with many other activities, including his duties as honorary secretary of the Zoological Society during a rather stormy period, and with the deputy chairmanship of the Advisory Council on Scientific Policy, towards the work of which and some of its sub-committees, notably the Committee on Scientific Man-Power, he has made a major contribution. He succeeds Sir Frederick Brundrett at a difficult time when it may well be that a closer integration between civil and defence science is necessary, and when indeed some re-thinking may be necessary on the balance between the two. For this task Sir Solly, by his previous experience, his exceptional ability and warm personality, is excellently qualified.

Meteorological Branch of the Canadian Department of Transport: Dr. Andrew Thomson, O.B.E.

DR. ANDREW THOMSON, who on September 25 retired from the post of director of the Meteorological Branch of the Canadian Department of Transport, a position he has held for the past thirteen years, is well known in the world of meteorology. A graduate of the University of Toronto, his first studies were in geophysics, and during 1920–21 he was put in charge of investigations into atmospheric electricity during the round-the-world cruise of the Carnegie Institution research ship. In 1923 he became director of the Apia Observatory, Samoa, and in 1929 aerologist of the Dominion of New Zealand. He returned to Canada in 1931 as head of the research division of the Meteorological Service, and assumed charge of the whole service in 1946. Dr. Thomson has done much in the international field, especially as a member of the Executive Committee of the World Meteorological Organization and as president of the Regional Association for North and Central America of the World Meteorological Organization. A great traveller, who has not only done much to build up an efficient national service but also to promote international co-operation in meteorology, he was made O.B.E. in 1948, and awarded the gold medal of the Professional Institute of the Public Service of Canada in 1952 and the honorary degree of D.Sc. by McGill University in 1958. He carries into his retirement the best wishes and affection of all who know him.

Mr. Patrick D. McTaggart-Cowan, M.B.E.

THE appointment of Mr. P. D. McTaggart-Cowan to succeed Dr. Andrew Thomson as director of the

Canadian Meteorological Service comes as no surprise to the world of professional meteorology, for he has been Dr. Thomson's right-hand man for many years. Mr. McTaggart-Cowan, who is forty-seven, was born in Scotland but has spent most of his life in Canada. After securing first-class honours in mathematics and physics at the University of British Columbia, he won a Rhodes scholarship to Corpus Christi College, Oxford, where he graduated with honours in natural science. He joined the Canadian Meteorological Service in 1936 and quickly became known internationally, especially in relation to trans-Atlantic aviation, then in its infancy. During the Second World War he was largely responsible for the development of forecasting at the Canadian end of the ferry flights to and from Britain. When hostilities ceased he took an active part in the formation of the body which has now become the International Civil Aviation Organization. Among professional meteorologists his name stands high, not only as a forecaster, but also as an energetic and skilful administrator, with a gift of clear thinking and direct speech. The future of the Canadian Meteorological Service could not be in better hands.

Chemical Engineering at Leeds: Prof. G. G. Haselden

Dr. G. G. Haselden, whose appointment to the new chair of chemical engineering at the University of Leeds has been announced, was educated at Sir Walter St. John's School, Battersea, and the Imperial College of Science and Technology, London. He graduated in chemical engineering with first-class honours in 1944 and afterwards undertook research under the late Sir Alfred Egerton on problems connected with the liquefaction of methane: on the results of this work he was awarded his Ph.D. In 1949 he was appointed lecturer and later senior lecturer in low-temperature technology in the Department of Chemical Engineering of the Imperial College. In addition to his teaching duties, Dr. Haselden has during the past ten years built up an active school in low-temperature research. His main fields of interest have been in the liquefaction of natural gas, the development of new or more efficient gas-separating processes and refrigeration cycles, and the measurement and correlation of the thermodynamic properties of mixtures. In 1958 he was awarded the Lightfoot Medal of the Institute of Refrigeration for his work on mixed refrigerants. Dr. Haselden was one of the founder members of the Low Temperature Group of the Physical Society; and he is a member of the Education and Papers Committees of the Institution of Chemical Engineers and a member of the Research Committee of the Institute of Refrigeration.

Illuminating Engineering Society Award: Dr. J. W. T. Walsh

To mark the occasion of its golden jubilee, the Illuminating Engineering Society has instituted an award to be known as the Illuminating Engineering Society Gold Medal, which will be bestowed at intervals of not less than two years for outstanding contributions to the advancement of lighting. Recipients of the medal may be of any nationality and need not be members of the Society. At the meeting of the Illuminating Engineering Society held in London on October 13, the first award of the gold medal was made to Dr. J. W. T. Walsh, who is without doubt the most outstanding and highly esteemed person in the world of lighting to-day. From Merton College, Oxford, Dr. Walsh went to the Department of Photometry of the National Physical Laboratory until he retired in 1951, having been there for thirty-eight years. His first outstanding contribution was the making of a large-scale photometric survey of factory lighting for the Home Office Departmental Committee in 1913. During subsequent years, he supervised much important work relating to the principles of good lighting and to the design and performance of lighting equipment, and he published a number of papers on all aspects of photometry and illuminating engineering. Dr. Walsh served for many years as chairman of the British National Illumination Committee and has participated actively in the meetings and work of international bodies concerned with lighting. He has served as honorary secretary and vice-president of the International Commission on Illumination and was president of that body from 1955 until June 1959. He has been a member of the Illuminating Engineering Society since 1923; he is the only member who has served two terms as president of the Society (1929 and 1947). He was chairman of the committee responsible for the current codes of practice for street lighting. Dr. Walsh has indeed been a prodigious worker in the cause of better lighting and this together with his high principles and strict regard for scientific accuracy has endeared him to lighting people all over the world. There is no doubt that his contributions to the advancement of lighting have been truly outstanding.

Royal Australian Chemical Institute: Mr. C. E. C. Nicholls

Mr. C. E. C. Nicholls has been elected president of the Royal Australian Chemical Institute. He was born and educated in England, and gained his degree in the University of London with honours in chemistry. After spending about two years with the British-American Tobacco Co., Ltd., he joined the Distillers Co., Ltd., in October 1929, very shortly after the latter company had entered the chemical field. He spent some years at the Company's main factory in Hull, and brought into operation the first synthetic acetic acid plant in England. Early in 1942 he was sent to Australia, where he played a major part in establishing the war-time synthetic acetone production. Early in 1945 Mr. Nicholls returned to England, where he resumed duties with the Distillers Co., Ltd. He made a short visit to Australia in 1946, and again in 1947 when the Colonial Sugar Refinery and the Distillers Co., Ltd., obtained a larger interest in Robert Corbett Pty., Ltd. He is at present manager of Colonial Sugar Refinery Chemicals Pty., Ltd., and a director of Robert Corbett Pty., Ltd. He was elected a Fellow of the Royal Australian Chemical Institute in 1947, holding office as president of the New South Wales Branch for two years and during the last year of this term he was also vice-president of the Institute.

Atomic Energy Authority's Thermonuclear Programme

The United Kingdom Atomic Energy Authority is seeking the necessary approvals to acquire and develop a site of some 175 acres within the perimeter of the Royal Naval Airfield at Culham, Oxfordshire, for development as a new research establishment. The new establishment would be for research into controlled thermonuclear reactions and plasma

physics and the study of nuclear fusion as a possible source of industrial power. Most of the thermonuclear research now carried on at Harwell and Aldermaston will be moved to the new establishment. One of the immediate tasks at the new site, if approved, would be the construction of I.C.S.E. (Intermediate Current Stability Experiments), a large machine which (as announced at the Authority's annual press conference in July) will incorporate the results of experience with *Zeta* and of other studies in this field, both at home and abroad. It is planned that the total numbers employed at the proposed new establishment will rise to 1,000 and that this figure will be reached within four or five years.

Divorce Statistics in Britain

THE principal changes that have been introduced in the Civil Tables of the Registrar General's Statistical Review for 1957 which has been published recently relate to divorce statistics (The Registrar General's Statistical Review of England and Wales for the year 1957. Part 2: Tables, Civil. Pp. xii+200. London: H.M. Stationery Office, 1959. 11*s*. 6*d*. net). Figures for divorces and annulments are now given by calendar year of marriage and age of spouses at marriage, so that the risk of divorce of different marriage cohorts may now be computed, and there are some other welcome new details on divorce. An appendix shows details of marriages by manner of solemnization in different countries. It is intended to publish this table at five-yearly intervals, and these data give a useful indication of the distribution of different religious groups in the country. It is of some interest that the proportion of civil marriages shows a fall, compared with 1952, for the first time since such marriages were instituted in 1836. In addition to these new figures, more detailed fertility tabulations giving better exposed-to-risk are also included in this volume.

Sex Research

THE Division of Medical Sciences of the National Academy of Sciences—National Research Council is accepting applications for grants-in-aid of research for consideration by the Committee for Research in Problems of Sex. The funds for support of this programme are provided by the Rockefeller Foundation and the Ford Foundation. The Committee is concerned primarily with encouraging research on the mechanisms underlying sexual behaviour, with special emphasis on the higher mammals and man. Proposals involving endocrinological, neurological, psychological, anthropological, phylogenetic and genetic studies directed toward this objective are therefore invited. Requests that deal with the physiology of reproduction or with related biological and biochemical fields should be addressed to the Committee only if they give promise of shedding light upon behavioural mechanisms. Preliminary inquiries should be addressed to Room 411, Division of Medical Sciences, National Academy of Sciences—National Research Council, 2101 Constitution Avenue, N.W., Washington 25, D.C. Completed applications for the fiscal year 1960–61 should be postmarked on or before January 15, 1960.

Variation in Lizards of the *Leiocephalus cubensis* Complex in Cuba and the Isla de Pinos

Leiocephalus cubensis Gray has been regarded as one of the four species of this genus in Cuba and the Isla de Pinos, and has been known to occur throughout both islands in suitable habitats. Albert Schwartz has collected 388 specimens and studied additional material from various museums; this has resulted in the partition of *L. cubensis* into two species, each with four subspecies. *L. cubensis* is now known from Cuba and the Isla de Pinos, the Doce Leguas keys, and the Archipiélago de los Canarreos, where the new species, *L. stictigaster*, occurs in western Cuba and the Isla de Pinos. The status of Oriente lizards of this complex remains uncertain. Schwartz believes that *stictigaster* and *cubensis* arose from a common stock through isolation on western and central island masses during the Oligocene and Lower Miocene Periods. With the re-establishment of the island to approximately its present outline between the Lower and Middle Miocene, these two species extended their ranges gradually from the regions of differentiation. From modern distribution it appears that the gap between western *stictigaster* and eastern *cubensis* may not yet be closed. *L. cubensis* also has spread to the east into Oriente as well as the west into Matanzas and Habana (*Bulletin of the Florida State Museum, Biological Sciences*, **4**, No. 4; 1959).

Transparent Sintered Alumina—'Lucalox'

SINTERED or vitrified ceramic materials of polyphase composition are normally opaque owing to scattering of light by the different refractive indices of the component phases. Single-phase sintered ceramics are usually both opaque and porous owing to the difficulty of sintering refractory substances sufficiently well to produce optical contact between the grains. The General Electric Co. of America announces the experimental production of a material, under the trade name 'Lucalox', which is formed by pressing from alumina powder of small grain size and fired under conditions, presumably *in vacuo* and at a very high temperature, which permit almost complete sintering to occur. The product is non-porous and sufficiently transparent for print to be read through a thickness of the material in contact with the paper. Objects viewed at greater distances are, however, blurred as though through frosted glass. It retains the refractory qualities of alumina, and is said to be stable up to about 1,900° C. Possible fields of use include envelopes for high-intensity light or radiant heat sources, as a superior alternative to fused silica. Light-transmission in the visible spectrum, through an unstated thickness, is said to be 90 per cent. Since the material is in effect a polycrystalline sapphire, it may offer an alternative to synthetic mono-crystalline sapphire for instrument bearings. Its electrical properties are not stated, but would presumably resemble those of sapphire; a permittivity of about 9·5, loss angle between 10^{-4} and 10^{-3} at room temperature, and appreciable conductivity appearing around 300–500° C., depending upon purity. The problem of production as a commercially satisfactory operation is said to be still under investigation.

International Conference on Non-Destructive Testing

THE third International Conference on Non-Destructive Testing will be held in Tokyo during March 15–21. The Conference is intended to provide an opportunity for the exchange of information on

the latest development in scientific research and industrial application in non-destructive testing in different parts of the world and for the discussion of improvements in testing techniques. It will also deal with problems of international co-operation. The main part of the Conference will consist of four principal sessions (two in Tokyo and two in Osaka) and a number of technical sessions. Further information can be obtained from the secretary of the British National Committee for Non-destructive Testing, 1 Birdcage Walk, London, S.W.1.

University of Texas Grant for Genetic Research

The University of Texas has received a grant of 1,482,480 dollars, to boost basic research in genetics and cell biology over a five-year period, from the National Institutes of Health, the Public Health Service research centre at Bethesda, Md. The grant will support research in the areas of population genetics; genetic effects of radiation and cosmic rays; chromosome studies of cancer and normal cell strains; cytogenetics, and the physiological and biochemical aspects of genetics. Seven principal investigators, their associates and assistants working in the Genetics Foundation of the Department of Zoology, will conduct the research. Principal investigators will be Prof. W. S. Stone and Drs. C. P. Oliver, R. P. Wagner, J. J. Biesele, M. R. Wheeler, B. H. Judd and H. S. Forrest, all members of the University's Genetics and Cell Biology Group.

Royal Meteorological Society: Officers for 1959–60

The following have been elected officers of the Royal Meteorological Society for 1959–60: *President*, Dr. J. M. Stagg; *Vice-Presidents*, Dr. H. L. Penman, Prof. P. A. Sheppard, Dr. G. D. Robinson and Dr. R. M. Goody; *Vice-President for Canada*, Dr. W. L. Godson; *Vice-President for Scotland*, R. Cranna; *Treasurer*, B. C. V. Oddie; *Secretaries*, P. J. Meade, Dr. R. S. Scorer, J. S. Sawyer (editor) and Dr. A. G. Forsdyke (librarian).

University News: Cambridge

Mr. G. R. Crowe, who joined the Cavendish Laboratory more than fifty years ago and was well known as personal assistant to Lord Rutherford, has had conferred on him the honorary degree of M.A.

Leeds

The following grants are announced: from the Department of Scientific and Industrial Research, £1,835 towards the cost of cosmic-ray research in the Department of Physics, £12,000 over three years for an investigation into high-pressure chemistry and geochemistry in the Department of Chemistry, £3,000 over three years for research by Dr. P. Gray in physical chemistry, and £1,050 for research in high alumina cements in the Houldsworth School of Applied Science; 6,000 dollars a year for two years from W. R. Grace and Co., of the United States, for a research fellowship in physical chemistry; £1,422 from the Marine Biological Association for research on the electron microscopy of marine flagellates; £3,000 for 1959–60 from the National Coal Board, North-Eastern Division, and £1,000 from Richard Sutcliffe, Ltd., for research in mining; and from the Agricultural Research Council for two research projects, £1,893 in the Department of Agriculture and £2,807 for research into the interpretation of fibre types in sheep in the Department of Anatomy.

Lectureships are announced as follows: Mr. D. I. Davies (Department of Organic Chemistry); Mr. A. R. J. Gaskin (Department of Geology) as from October 1; Mr. A. N. Hillas (Department of Physics); Mr. M. D. Longfield (Department of Mechanical Engineering) as from January 1, 1960; Mr. A. R. Mathieson (in the chemistry of high polymers in the Department of Textile Industries) from January 1, 1960.

London

The title of professor of virology in the University of London has been conferred on Dr. Forrest Fulton in respect of his post at the London School of Hygiene and Tropical Medicine. The title of professor of epidemiology in the University of London has been conferred on Dr. D. D. Reid in respect of his post at the London School of Hygiene and Tropical Medicine. The title of reader in pharmaceutics in the University of London has been conferred on Dr. D. Train in respect of his post at the School of Pharmacy.

Announcements

Mr. Ernest Turner Jones, deputy controller (Overseas Affairs) Ministry of Aviation, has been elected deputy chairman of the Nato Advisory Group for Aeronautical Research and Development. Mr. Jones is the first deputy chairman to be appointed by the Group, of which Dr. Theodore von Karman has been chairman since its inception in 1952.

Dr. Norman G. Gaylord, vice-president of research and development of the Polymer Division of the Western Petrochemical Corporation and a senior lecturer at the Polytechnic Institute of Brooklyn, has been appointed editor of *Resins, Rubbers, Plastics*, the loose-leaf abstract service issued monthly by Interscience Publishers, Inc., New York. It is hoped to accelerate the publication of abstracts of foreign as well as American articles, and the organic aspects of polymer chemistry will be given a greater emphasis than in previous volumes. The subscription price of *Resins, Rubbers, Plastics* is 90 dollars.

The third Australian Nuclear Research Foundation Summer School for Science Teachers is to be held during January 11–20, 1960, at the University of Sydney. Each science teacher attending the School is to be paid an amount to help defray expenses he may incur in so doing. The total costs of the 1960 School will be in excess of £13,000. The following donations have been made towards these expenses: Philips Electrical Industries Pty., Ltd., £3,500; Ampol Petroleum, Ltd., £2,500; W. D. and H. O. Wills (Australia), Ltd., £3,500. Further information can be obtained from Dr. S. T. Butler, Department of Physics, University of Sydney, Sydney, New South Wales.

Errata. We regret that one of the names appended to the communication entitled "Light-induced Production of Carotenoid Pigments by *Cephalosporia*" in *Nature* of August 29, p. 741, was incorrect; the authors are "R. C. Codner and B. C. Platt".

In the communication entitled "Bence Jones Proteinuria associated with a Transplantable Mouse Plasma-Cell Neoplasm" in *Nature* of August 22, p. 654, column 1, par. 2, lines 4 and 8, for "α-globulin" read "γ-globulin"; par. 6, line 3, for "β-globulin" read "γ-globulin". Footnotes 4 and 8 should read "Fahey, J. L. . . ." and "Osserman, R. M. . . .", respectively.

MELLON INSTITUTE

REPORT FOR 1958–59

THE annual report of the chairman, M. B. Ridgway, to the Board of Trustees of the Mellon Institute for the year ended February 28, 1959, records an increase in the Institute's independent research staff from 22 to 56, while a further 254 scientists and their assistants were engaged on the 47 industrially sponsored applied science fellowships and projects at the close of the year (Scientific Research in Mellon Institute 1958–1959. Pp. x+38. Pittsburgh: Mellon Institute, 1959). A plan was developed for industrial affiliation with the fundamental research sector of the Institute's programme whereby co-operation can contribute to the support of fundamental research in a designated area.

During the year the independent research programme embraced studies of some of the properties of a group of esterases, with special reference to the cholinesterase of human blood plasma. A rapid ultraviolet spectrophotometric method was developed for the assay of hydrolysis of certain substrates and evidence obtained that promotion of enzyme activity depends partly upon a competition between the activator and the substrate for a negatively charged site on the enzyme. Studies of fibrogenesis in collagen solution were undertaken to explore the spatial arrangement of the protein amino groups which are regarded as responsible for the characteristic bands observed in collagen fibrils with the electron microscope. Investigations continued on the mechanism of enzymatic hydroxylation and on the chemical structures of two metabolites of *p*-aminobenzoic acid.

In inorganic chemistry the relatively little-known chemistry of osmium was studied, and besides the discovery of univalent osmium evidence for a zero-valent osmium complex was obtained. For studies of the magnetic properties of transition metal compounds a magnetic susceptibility balance was set up, utilizing a 'Varian' 4-in. electromagnet and a vacuum microbalance. A further programme is concerned with the formation, reactions and structures of inorganic species containing cation–oxygen, cation–hydroxyl and cation–water linkages, while studies in the chemistry and physics of natural and synthetic macromolecular substances continued to develop. The contribution of the chain configuration to the internal energy of a polymer has been determined from the dependence on temperature of the stress of the cross-linked polymer. This occurs when stretched in the amorphous state, and for polyethylene and poly*iso*butylene this energy effect can be correlated with independently estimated energy differences between the principal bond conformations. Stress–temperature measurements on fibres prepared from muscle by extraction and chemical cross-linking can be satisfactorily interpreted as due to reversible melting and crystallization processes. Studies on branched-chain polymers have sought to synthesize molecules of precisely known structure and to correlate their physical properties with the chain architecture. These included a theoretical analysis of the distribution of molecular weight resulting from the formation of branched molecules, while investigation of the statistical thermodynamics of dilute polymer solutions continued. A theoretical study of the diffraction pattern of a crystal containing a single dislocation indicates that it is doubtful whether or not double-crystal spectrometer measurements can be used to obtain dislocation densities from first principles.

In the fields of organic chemistry the structure of the alkaloid skytanthine has been firmly established by a combination of classical degradation and instrumental methods. The existence in cyclic sulphite esters of a stereoisomerism arising from the non-coplanarity of the sulphite group has been demonstrated by a nuclear magnetic resonance method. The kinetics of the dehydrohalogenation and rearrangement of 1 : 1-diarylhalogenoethylenes have been studied and also the possible extension of the reaction to purely aliphatic and alicyclic systems. Installation of a 'Varian' dual-purpose nuclear magnetic resonance spectrometer operating at 60 Mc./s. has greatly assisted the solution of many organic analytical problems. From July 1, 1958, the half-time responsibility for service research in the Institute's former Department of Research in Chemical Physics was transferred to the newly established Research Services. High-resolution infrared absorption measurements have been conducted by the matrix isolation technique at temperatures as low as 4·2° K. on the photolysis products of ammonia, 1 : 2-diazine and azomethane; survey spectra of about 150 inorganic salts containing polyatomic ions have been obtained in the cæsium bromide region (700–300 cm.$^{-1}$) using a special long wavelength infra-red spectrometer and a Raman apparatus with red excitation. Crystal diffraction studies of simple organo-silicon compounds are being pursued; the structure of dicobalt octacarbonyl is under investigation for information about the bonding of the cobalt atoms, while new relations between thermodynamics and continuum mechanics have been revealed in an investigation of the axiomatization of thermodynamics. Current studies in radiation research include the radiation decomposition of hydrocarbons, using gas chromatography for analysis, the kinetics of photochemically produced free radicals and the radiation-induced cross-linking of polymers in solution. During the year five fellows were appointed in organic chemistry.

Fellowship investigations under 'metals programme' include the thermodynamics of systems of importance to the steelmaker, a long-range research and development programme to evaluate ferrous alloys for high strength, particularly at high temperatures, and the physical metallurgy of semi-conductor devices. Continued attention was given by the Artists' Materials Fellowship to the fading of pigments and loss of solubility of varnishes in light. The chemical hygiene fellowship is giving increased attention to the safety of food additives. Under the water pollution abatement fellowship a paper chromatographic technique has been developed for determining fatty acids in water, and a continuous counter-current extractor is being used to recover soluble organic matter from river water. Under the organic synthesis fellowship, heterocyclic derivatives, such as imidazolines, hexahydropyrimidines and perhydrotriazones, which give excellent crease resistance to cotton, have been

prepared; the study of emulsion paints comprising homo- and co-polymer systems has indicated a correlation between water-resistance, hardness and flexibility of latex films, and polymer composition; and the investigation of polyethers from polyols and propylene oxide has assisted the rapid growth of the polyurethane foam industry. Both the coal chemicals fellowship and the petroleum fellowship cover a wide field and, under the power rectifier fellowship, laboratory development of the first new power rectifier was completed and the growth of highly perfect single crystals of silicon and germanium has been studied. New organosilicon compounds, monomers and polymers have been prepared under the silicones fellowship, including some hybrid organotin organosiloxane compounds.

LABOUR TURNOVER

LABOUR turnover has been a subject of inquiry and discussion since interest was first focused on the problem during the First World War. It is commonly regarded as a source of serious economic waste. The level of turnover in a firm is often regarded as an index of morale among the employees.

Research workers have attempted to analyse the causes of labour turnover by relating it to different groups of factors. The most important of the external factors are the level of employment and the availability of alternative work. The internal factors are the composition of the labour force itself, that is to say, whether men or women are employed, whether they are skilled or unskilled; the length of time workers have been employed, their age and the location of their homes. Wage rates, hours and conditions of work and the personal relationships existing within a firm may also have important effects on labour turnover.

The findings of research do not appear to have helped managements very much in their efforts to reduce labour turnover. The British Institute of Management survey of 1949 and 1950, covering approximately two hundred companies, showed annual labour turnover rates varying from 13 per cent to 59 per cent for men and from 24 per cent to 75 per cent for women per annum. These are industry rates. Individual companies fluctuated below and above this range. Labour turnover was calculated on the basis of:

$$\frac{\text{Number of leavers in period under review}}{\text{Average number of persons employed during same period}} \times 100$$

Commonly agreed facts about labour turnover are that in any given period it is heavier among short-service employees than among those of longer service and that much of it does not represent true mobility but, from the social point of view, useless changes from one job to another.

What has not been established is to what extent labour turnover matters to the individual company and to society and the extent to which labour turnover can be measured in financial terms or whether its effects are largely intangible and in any event non-financial.

Excessive labour turnover is assumed to cause waste and inefficiency. Few studies have attempted to find out what exactly is the extent of this waste. One of the drawbacks is the difficulty of measurement. The effects of labour turnover are widespread and varied and attempts to assess them in financial terms can easily become either over-simplified or over-imaginative and remote from verifiable facts.

An appraisal of the importance of labour turnover to industry cannot be complete unless there is some estimate of its financial effects. Certain effects as, for example, the impact on the morale of the working group of a continually changing labour force, cannot be assessed in financial terms. The more tangible costs are also important.

What has been needed is a series of published case-studies of the experience and of the financial cost of labour in individual concerns. The British Institute of Management has now published a series of sixteen such studies*. The studies have been of the cost of labour turnover among direct production workers. No studies have been undertaken among clerical or selling staff.

The data provided by these case-studies and by supplementary information obtained from a large number of firms show that:

(1) In five out of sixteen studies, labour turnover was adding 10*s.* or more per week to the wage cost of each individual employed.

(2) The main factors which appear to affect labour turnover cost are the impact of learners on production, the extent to which saleable production is lost through labour turnover and the methods used to make up production losses.

(3) The amount spent on training, induction and interviewing is a matter of company policy and will naturally affect the level of its labour turnover cost. Money spent in this way, however, has a constructive result and is not waste, as is the cost arising from other categories.

(4) Labour turnover has certain long-term effects which are not measurable in financial terms. Most important of these are the effect of high labour turnover on the morale of the work force, the wear and tear on supervisory staff and the loss of customers' goodwill by failure to fulfil orders and to meet delivery dates. To combat these effects by reducing labour turnover, it seems worth spending money on training, induction and interviewing.

(5) Labour turnover appears to be most costly in those firms where there is a high proportion of semi-skilled jobs peculiar to the company itself. This is because the training period is often long and it is rare to find new employees with experience of similar work. The recognized skilled occupations and the relatively unskilled ones, for example, labouring and cleaning, do not involve companies in high training costs.

(6) The results of the inquiry as a whole suggest that keeping labour turnover low may be a relatively expensive business, almost as expensive as allowing it to increase with consequent increased production costs and sales losses. The decision about how much to spend on reducing labour turnover must be based not only on the figures of tangible waste but also on management's estimate of the seriousness of the non-financial aspects.

T. H. Hawkins

* "Cost of Labour Turnover", 17*s.* 6*d.*

STRONTIUM-90 IN HUMAN DIET

RESPONSIBILITY for estimating the contamination of food by radioactive fall-out has now been transferred to the Agricultural Research Council. The report, "Strontium-90 in Human Diet in the United Kingdom, 1958" (London: H.M. Stationery Office, 1959. 4*s*.), thus continues the series formerly issued by the Atomic Energy Authority.

The general level of radioactivity in food in the United Kingdom for 1958 was small, comparable with that found in the United States, and well below any danger-level. Most of the radioactivity in milk and dairy products, bread and flour, and in leafy and root vegetables, was brought about by the deposition of radioactive debris on the leaves of herbage and crop plants during periods of rain, followed by foliar absorption of (in particular) strontium-90. Only the material deposited during the two months before herbage was eaten by cows or before crops were harvested appeared afterwards in appreciable amounts in human food. Once the debris penetrated into the soil, its 'availability' to plants was greatly reduced. Consequently, the accumulation of available strontium-90 in the soil since nuclear weapon testing commenced in 1945 had been slight.

The radioactivity of milk was highest in western areas of Britain and appeared to be related to the distribution of rainfall. The level of radioactivity increased in all areas during the latter half of 1958, partly as a result of an unusually high rainfall and partly of an increase in the number of nuclear tests.

Examination of certain upland areas that are characterized by high rainfall and by slow growth of herbage had shown that milk from these areas often contained very high levels of strontium-90. This could not be accounted for entirely on the basis of high rainfall, low soil-calcium, and low production of herbage per acre. It was thought that strontium-90 must become entrapped in the mat of vegetation and roots at the base of the sward, and be held available to the plant in successive seasons, in a way not observed on lowland pastures.

The report shows that when strontium was absorbed from the diet, it tended to replace calcium in bone tissue. High levels of strontium-90 in bone could damage the bone or bone marrow, ultimately causing tumours, leukæmia, or other bone diseases. However, it appeared that the replacement of calcium by strontium-90 in new bone tissue was governed not by the amount of strontium-90 in the diet but by its proportion relative to calcium (expressed as micromicrocuries of strontium-90 per gm. calcium). Furthermore, the human body, in absorbing mineral substances from the digestive tract, discriminated against strontium, so that the ratio of strontium-90 to calcium which was found in bone was only one-quarter of that in the food eaten.

The report also discusses other factors which tended to reduce the ratio of strontium to calcium in the diet. Thus, the cow discriminated against strontium when producing milk from grass, so that the proportion of strontium-90 to calcium in milk was only one-seventh of that in the herbage eaten. Leafy vegetables appeared to absorb strontium less efficiently than herbage, and contained correspondingly less radioactive material. Although wheat contained a fairly high proportion of strontium-90, milling, as in the preparation of white flour, removed much of the calcium and strontium in bran and offal, while the subsequent addition of strontium-free chalk as a calcium supplement further reduced the proportion of strontium to calcium in bread and flour products. The report noted that the ratio of strontium-90 to calcium in diets based on wholemeal bread was likely to be higher than average, as there was no legal requirement to add chalk to wholemeal flours, while the milling process did not tend to remove any of the strontium contained in the grain.

However, even on the most unusual food and living in the wettest area, no one in the United Kingdom was likely to consume a diet containing more than 23 μμc. of strontium-90 per gm. calcium, about half the ratio (40 μμc.) at which a Medical Research Council Committee thought that 'immediate consideration' should be given to the problem. It is emphasized that no evidence had been found of such a diet being consumed by anyone. The amount of strontium-90 per gm. calcium in the average diet was about 6 μμc., and, provided that the rate of deposition of the radioactive dust did not greatly increase in the future, either as a result of meteorological factors or because of further testing of nuclear devices, such a level should give no cause for anxiety.

J. M. A. TILLEY

IMMEDIATE AND LOW-LEVEL EFFECTS OF IONIZING RADIATIONS

THE biological effects of low doses of ionizing radiations, a topic of obvious interest and importance, formed one of the main themes of a symposium held in Venice, June 22–26, under the joint sponsorship of Unesco, the International Atomic Energy Agency and the Comitato Nazionale per le Ricerche Nucleari of Italy. The Organizing Committee included Prof. Z. M. Bacq (Belgium); Profs. E. Boeri and A. A. Buzzati-Traverso (Italy); and Dr. A. Hollaender (United States). Those invited were fortunate in being able to take part in a conference of which content and programme arrangements were of a high order, and which was held in the beautiful surroundings of the Fondazione Giorgio Cini, on the Isola di San Giorgio Maggiore. Each of the nine sessions was arranged to contain only a few papers, so that there was ample time for discussion and for a few short communications which were relevant to the main themes. Sixteen countries, and a wide range of scientific disciplines, were represented among the 116 research workers who took part.

The symposium opened with a review of certain aspects of quantitative radiobiology by K. G. Zimmer (Kernreaktor, Karlsruhe, Germany). After discussing

critically some of the postulated mechanisms of the biological action of ionizing radiations, he went on to describe recent results obtained by the use of microwave spectroscopy. This topic, discussed also by J. S. Kirby-Smith (Oak Ridge, United States), is of great interest because persistent magnetic centres can be observed in irradiated biological materials of low water content, and the signals are modified by environmental factors which are known also to modify the biological effects of radiation. However, caution is necessary in interpreting the results obtained by instruments currently in use, since the signals observed arise from about 10^{10} times as many ionizing events as those which in many cases initiate biological damage.

New techniques which have recently been developed for studying cells in mitosis have enabled investigators to undertake the difficult task of observing quantitatively the induction of chromosomal abnormalities in human cells. M. A. Bender (Oak Ridge, United States) had examined effects on human cells in tissue culture, and also on monkey cells *in vivo*, using bone marrow. The cells irradiated *in vivo* gave a somewhat lower yield of chromosome aberrations. Doses down to 25 r. were used in these studies.

The effects of considerably lower doses on human cells were observable by M. Ingram (University of Rochester, United States), who had found significant increases in the number of binucleate lymphocytes present in the blood of persons exposed to doses considered to be in the 'tolerance' range. Although ionizing radiation is not the only agent which can bring this about, it was of interest that in a field investigation of uranium miners, a higher count of binucleate lymphocytes was found in the blood of the control group of coal miners, who had been subjected to regular routine diagnostic X-ray examination! Another paper on effects of X-irradiation on the blood picture of mammals was given by S. Hajdukovic (Institute for Nuclear Sciences, Yugoslavia), who used as his test effect the increase in the number of reticulocytes released into peripheral blood. He reported that increases were also obtained when serum from irradiated animals was injected into non-irradiated ones, the effect not being species-specific. These changes were observed fairly early after the irradiation.

The subject of chemical protection against biological effects of ionizing radiation was reviewed by D. W. van Bekkum (National Defence Research Council, Holland), who discussed different groups of protective substances and critically examined possible mechanisms of action. R. Brinkman (State University, Groningen, Holland) described techniques for examining the protective effect of chemicals against radiation-induced changes which could be measured very soon after low doses of irradiation. These included measurements of the viscosity of synovial fluid, and of intradermal pressure. Effects of irradiation could be observed within one second, and serotonin injected intradermally was the most effective of the protective substances used. M. Ebert and A. Howard (Medical Research Council and British Empire Cancer Campaign, Great Britain) described some of their latest findings with inert gases. These gases suppressed the enhancing action of oxygen when used at pressures above atmospheric, but were less effective in the cold than at room temperature. J. F. H. Maisin (University of Louvain, Belgium) had found that small doses of radiation could themselves protect against the damaging effect of larger doses. Yeast cells were exposed for long periods to continuous irradiation which was not itself sufficient to kill the cells; thereafter, larger doses were required to produce a given killing effect on these than on control cells. Rats which had been exposed to radiation *in utero* or as new-borns were more resistant than controls to radiation given afterwards.

Various types of immediate response to irradiation had been observed by O. Hug (International Atomic Energy Agency, Austria), who showed a film which demonstrated reflex reactions of snails, sea urchins and ants. It was clear that an immediate effect of radiation could be observed with nerve tissue, long thought to be comparatively insensitive to its action. A different type of immediate response was reported by A. Forssberg (Institute of Radiophysics, Sweden), who has observed reversible effects of doses as low as 10^{-3} r. on the fungus *Phycomyces blakesleeanus*, the growth-rate of the sporangiophore being immediately reduced. Depression of growth-rate was accompanied by an increase in the level of acid-labile phosphorus, and a slightly delayed increase in lactic acid. It was suggested that the use of adenosine triphosphate might be blocked by the radiation.

Radiobiologists continue to search for the biochemical links between the absorption of ionizing energy and the manifestation of the effects observed, and various approaches were reported. P. Alexander (Chester Beatty Research Institute, Great Britain) gave an account of physico-chemical studies on effects of radiation on deoxyribonucleic acid *in vitro* and in herring sperm, including a discussion of the phenomenon of cross-linking. K. I. Altman (University of Rochester, United States) had studied the breakdown of muscle collagen in rats previously fed with labelled amino-acids. Whole-body irradiation with lethal doses was followed by a reduction in the hydroxylation of proline and an increase in that of its precursor.

A. Chevallier and S. Manuel (University of Strasbourg, France) found that one result of radiation which could be measured within a short time was a drop in the ascorbic-acid content of almost all tissues, particularly the spleen. While this was true of animals irradiated as a whole, spleen slices irradiated *in vitro* did not demonstrate the phenomenon, nor was it observed when only the exteriorized spleen was irradiated. The authors concluded that the drop in ascorbic acid in the spleen depended on effects on other organs. P. Mandel and P. Chambon (University of Strasbourg, France) reported studies on ribonucleic acid synthesis in rat spleen after whole-body irradiation. Accumulated nucleotides were found in this organ from 12 hours after irradiation. R. Goutier, M. Goutier-Pirotte and P. Ciccarone (University of Liège, Belgium) examined an effect which occurred soon after the comparatively low dose of 150 r. (whole-body) to rats. Changes in the deoxyribonuclease activity of the spleen could be detected after half an hour. The activity of the extracted enzyme depended critically upon the methods used in preparing the sample. The authors considered that the effect was due to a change in the enzyme molecule, and not to the effect of the irradiation on enzyme distribution.

H. I. Adler (Oak Ridge, United States) reported on observations with a variant of *Escherichia coli* which did not synthesize catalase. One effect of irradiation was to sensitize the cells to the action of hydrogen peroxide. Irradiated cells exposed to its action were killed, although they would otherwise have survived.

Bacteria were used in two studies of the effects of low doses of radiation. Marcovich (Institut du Radium, France) had examined the induction of lysogenic bacteria, and concluded that the passage of a single ionizing particle through a cell was sufficient to bring about this effect. M. Demerec (Carnegie Institute of Washington, United States) made use of three biochemical mutations which occurred spontaneously with very low frequency, so that the genetic effects of doses as low as 8·5 r. could be assessed. In all three cases, the number of mutations induced was proportional to the dose at low doses, though the doses required to produce a given frequency of mutations differed for the three mutations chosen for study.

New observations on the genetic effects of ionizing radiation on mice were reported by W. L. Russell (Oak Ridge, United States). These have confirmed his previous report that if a dose in the range 200–600 r. was delivered at 80 r./min. more mutations were induced in spermatogonia than if the same dose was delivered continuously as 'chronic' irradiation at 90 r./week or less. This did not apply to mutations induced in spermatozoa. The genetic effect of a single dose on oocytes was greater than on spermatogonia, whereas the reverse was true of chronic irradiation. L. B. Russell (Oak Ridge, United States) reported that chronic irradiation was less effective than an acute dose, delivered to embryos in their most sensitive stage, in bringing about still-births and neonatal deaths.

Various tests of radiation damage were used by L. J. Cole (Naval Radiobiological Defense Laboratory, United States) in comparing effects of single exposures and 'chronic' or fractionated radiation. Single doses were less effective in inducing leukæmia or shortening the life span; but the effects of chronic irradiation doses on the fertility of female mice were much lower than were single doses. The effect of as little as 25 r. in a single dose could be detected in weanlings. The injection of bone marrow, which protected against the lethal effects of 800 r., did not protect against loss of fertility.

Immunological aspects of tissue transplantation after 300 r. of X-rays had been studied by P. C. Koller and S. Doak (Chester Beatty Research Institute, Great Britain). After fifty days, the immune response of some 'chimaeras' had reverted to the host type, others had retained the immunity of the donor, and yet others gave a mixed response.

This very brief account of the subjects discussed at the symposium should make it evident how wide a range of materials, and how many different approaches, are being used in attempts to clarify some of the outstanding problems in radiation biology. The proceedings of the symposium are to be published as a supplement to the *International Journal of Radiation Biology*.

TIKVAH ALPER

NUCLEAR FORCES AND THE FEW-NUCLEON PROBLEM

MORE than 250 nuclear physicists, including about 100 delegates from fifteen countries overseas, attended the international conference, which was held at the Physics Department, University College, London, during July 8–11. A conference on the behaviour of light nuclei had not taken place for several years and was initiated by physicists at Los Alamos and University College. As was stressed by Prof. H. S. W. Massey (University College), who opened the conference, although the original intention was to emphasize the few-nucleon problem, discussion of nuclear forces had inevitably to be included.

The conference consisted of five main sessions, the first and longest being entirely devoted to the primary two-nucleon interaction. In this session review papers were given by Profs. R. E. Marshak (Rochester), R. Wilson (Harvard), K. A. Brueckner (Pennsylvania) and G. F. Chew (Berkeley) on both the experimental and theoretical status of the problem. Interest centred on many sets of measurements, including triple scattering and correlation experiments, as well as more accurate cross-section measurements at various energies and on their interpretation in terms of the S-matrix. Prof. G. Breit (Yale) presented an extensive search for phase-shift fits to the scattering data up to 340 MeV., while comparison was made with phase-shifts derived from various phenomenological potentials by Prof. Marshak. There was discussion on both the necessity and theoretical justification for including spin-orbit and other velocity-dependent potentials in the two-body force. The experimental papers were concerned with recent triple scattering measurements in p–p scattering at Rochester and Harwell and with p–p angular distributions at Minnesota. Also n–p angular distributions and polarization measurements from 20–120 MeV. were reported by Dr. J. J. Thresher (Harwell).

Dr. J. Iwadare (Kyoto) summarized the recent work done in Japan on the meson-theoretical two-nucleon interaction and its comparison with experimental data. This was followed by Prof. Chew's paper, which reviewed recent work on the meson field-theoretical approach to the two-body problem starting from the Mandelstam conjecture on the analytical form of the scattering amplitude. The inclusion of the pion–pion interaction within the context of dispersion relations seems to be the next step in the long struggle to obtain meaningful results from the meson theory of nuclear forces proposed by Yukawa in 1935.

Prof. Yukawa was chairman for the beginning of the second session, on the scattering of nucleons by light nuclei at high energy. A review paper on the impulse approximation by Dr. H. McManus (Chalk River) was followed by applications of this approach to the n–d and p–d case by Drs. L. Castillejo (Birmingham), R. Phillips (Harwell) and by Japanese workers. The problem was examined from the point of view of dispersion theory in a paper by Goldberger, Halpern and Blankenbecler (Princeton), and corrections due to multiple scattering were considered by Prof. R. J. Glauber (Harvard). In this session there were reports by Drs. A. M. Cormack, T. C. Griffith and G. Huxtable on experiments done at Harvard, University College and Harwell respectively on p–d and p–α scattering at energies between 50 and 150 MeV.

The session on photonuclear reactions with light nuclei opened with a review by Dr. D. Dixon

(Glasgow). Other papers were presented by Profs. G. Breit, A. Klein (Pennsylvania) and Dr. Iwadare. The effect on the theory of the photodisintegration of the deuteron of the spin-orbit force within the n–p system stimulated much discussion.

The fourth session of the conference was devoted to the question of binding energies and elastic scattering of light nuclei at low energies. The review papers were given by Prof. H. S. W. Massey and Dr. P. G. Burke (University of London) on the three-body problem and on the elastic scattering of nucleons by alpha-particles. There were also two invited papers from Los Alamos: Dr. L. Cranberg reported on experimental results concerning total and differential cross-sections and also polarization measurements in the scattering of low-energy neutrons from ^{2}D, ^{3}H and ^{3}He, while Dr. L. Rosen reported on charged particle scattering from ^{2}D and ^{3}H at energies up to about 20 MeV. These experiments led to several new checks on charge symmetry and time reversal invariance.

The contributed papers included one on the ground-state energy of the triton, by Prof. J. M. Blatt (Sydney). Using the Gammel–Thaler potential, no bound state was found for reasonable trial wave functions. Among other papers from Los Alamos, Dr. J. L. Gammel gave a preliminary account of attempts to integrate the n–d problem numerically and discussed the feasibility of spin-correlation experiments using ^{4}He as an analyser.

Polarization measurements in n–d and p–d scattering at low energies, reported by Dr. H.-J. Gerber (Zurich) and Dr. R. E. Segel (North-western University), indicate that there is very little polarization at about 4 MeV. A contribution from Dr. N. Vlassov (Moscow), read by Dr. I. A. Baz, on the interaction of protons and deuterons with light nuclei ended this session.

The last session, with a title "Reactions Involving Four or More than Four Nucleons", was opened by Dr. B. H. Bransden (Glasgow) with his paper on the collisions of neutrons and of deuterons with ^{3}H and ^{3}He. This paper was followed by a number of papers involving the application of the resonating group structure method to binding energy and scattering calculations. This method, as did the impulse-approximation method at higher energies in a previous session, aroused considerable controversy during the discussion. Nevertheless, it was felt that some progress had been made, since one type of mixture of exchange forces does seem to be simulating the exact force in more than one situation involving light nuclei.

Prof. G. Skornyakov (Moscow) then gave his paper on n–d scattering in the zero-range force approximation, this being a contribution to the previous session. The three-particle problem is solved accurately in this limit. He also read a paper by Dr. T. Y. Barit on p–T scattering and allied reactions.

The final papers were preceded by a review given by Dr. V. J. Emery (Harwell) of the calculations of the binding energies of nuclei using the Brueckner method. Prof. Brueckner himself also presented a paper on the Hartree–Fock method for strongly interacting systems. The conference concluded with papers by Profs. N. Austern and S. Meshkov (Pittsburgh) on preliminary calculations concerning the structure of ^{6}Li and ^{12}C.

T. C. Griffith
E. A. Power

CHAGAS'S DISEASE

Chagas's disease or South American trypanosomiasis, occurring chiefly in Brazil and other countries of South America, is caused by *Trypanosoma cruzi* and is spread mainly by reduviid bugs. The disease was first discovered and described fully in 1909 from the State of Minas Geraes in Brazil. All the significant observations regarding the causative agent, the vector, mode of transmission and symptoms were made then, by that creative genius, Carlos Chagas. In order to commemorate the fiftieth anniversary of this discovery, an international congress on Chagas's disease was held at Rio de Janeiro during July 5–11.

Foreign delegates from European countries, Israel and the United States of America numbered more than seventy. Approximately 300 others from Brazil and the neighbouring countries of South America also attended. At a short historical session at the Ministry of Education and Culture on July 4 the life and work and significance of the discoveries made by Chagas were described by various speakers.

The inaugural meeting of the congress was held on July 5 in the National Faculty of Medicine from 9 p.m. until midnight, when addresses were delivered by Prof. Alessandri (Chile), Prof. Lemoigne (Pasteur Institute, Paris), Dr. Candau (director general, World Health Organization), a student in the Medical Faculty, Prof. Moraes, director of the Medical School and dean of the University, and replied to by Prof. Carlos Chagas Filho.

The real business of the congress began on the following morning at 9 a.m. and lasted until 6 p.m. in a pavilion within the grounds of the Instituto Oswaldo Cruz. Two or three sessions took place concurrently to discuss the disease in its different aspects. In one of the lecture theatres simultaneous translations from English, French, Spanish, Portuguese and German were provided. Chagas's disease in the American continent was discussed from the pathological aspect and the different forms encountered in the various South American countries described, including the clinical findings on the two human cases thus far reported from the southern United States. Other papers on transmitting agents, animal reservoirs, including the opossum and armadillo, and their relation to the epidemiology of the disease as well as the characters of the human strains, were discussed. Public health questions were reviewed in relation to the geographical distribution of the principal transmitters of the disease which infest human dwellings. The anatomy and respiratory system of *Triatoma infestans*, the chief vector in Brazil, was described. On the following day the subject discussed in one section was the ætiological agent, with emphasis on the physiology, metabolism and nutrition of the parasite. Electron microscope studies of parasitized cells were included. In another section immunological aspects of the disease, including complement fixation reactions, precipitin and skin tests, were dealt with and the isolation of

immune polysaccharides from the organism described. The occurrence of toxins in cultures of the organism appeared to be doubtful. The epidemiology of the disease was discussed in seven papers. Polymorphism which occurs in African trypanosomes was compared with that met with in *T. cruzi*, and observations made on the nature of their evolutionary cycles. The session was concluded by the showing of a film dealing with methods of eradication of the tsetse fly, which transmits the disease in Portuguese Africa. On the same evening a meeting was held in the Brazilian Academy of Sciences from 9 p.m. until midnight, at which a paper was read on "Chagas as Protozoologist", and others on the metabolism, phylogeny and growth of the parasite. The following day was devoted to the pathology of acute and chronic cases of the disease in different parts of the South American continent, throughout which the virulence of the causative agent varies. Discussions took place on the myocardial, nervous, cerebrovascular and blood protein changes involved, as well as on the condition of megacolon and megacesophagus now believed to be causally related to the disease. Further papers on epidemiology dealt with animal reservoirs and with the feeding habits of domestic and wild types of reduviid bugs. The danger of blood transfusion as a means of spread was also dealt with. Prophylaxis was best effected by spraying the sites where the vector was found, along with general hygienic measures. Workers from different areas of South America, where the nature of the problem varies with the transmitting agent, contributed also on the following day. The different clinical forms and diagnosis of the disease, including that met with in congenital cases, were described in seven papers. At a special session the nature of the infection caused by *Trypanosoma rangeli* was described. This parasite was first described in 1920 by Tejera in Venezuela, where it infects *Rhodnius prolixus*, which is also the chief transmitter of *T. cruzi* there. The first forms were seen in human blood in Guatemala in 1946, and now 795 cases of infection have been described in Venezuela, chiefly in children, but the infection is not of serious character. At an evening session in the National Academy of Medicine further papers were read. On the last full working day of the congress, eighteen papers were read, chiefly on the relationship of cardiac and nervous disorders, including megacolon and megacesophagus, to Chagas's disease. Discussions also took place on chemotherapeutic agents, but the sad fact remains that no curative agent is known for this disease. A short ceremony took place during the morning at which a plaque, presented by the Argentinian delegation, to the memory of Carlos Chagas was unveiled.

On the same day a paper was read by Prof. Jean Coudert on the action of *T. cruzi* extracts on cancer cells, another by William Frye on antibiotics in tropical disease, and Rene Dubos gave a talk on general aspects of infection.

The final meeting on July 11 was devoted to round-table discussion of the subjects dealt with earlier in the week. Resolutions were also submitted regarding the holding of another international congress within the next few years, but no definite decisions were arrived at. During the week more than 150 papers were read. Two medals were struck to commemorate the congress, each with the head of Carlos Chagas on one side, but differing on the obverse side. The proceedings of this inspiring congress will be published in due course.

J. D. FULTON

SPECIAL CERAMICS

THE challenge of temperature, which has inspired the metallurgist to some of his more notable developments, has in recent years been renewed and has been taken up by the ceramist, who is seeking materials of low creep resistance, high thermal shock resistance and high hot-strength to meet the demands of propulsion engineering, high-speed vehicles and nuclear engineering. The ceramist has for many years made his own special contribution to communications engineering, chiefly in the exploitation of oxide-type materials; the field of non-oxide materials remained largely unexplored, but it is now being opened up by the drive for new materials in other engineering applications. The British Ceramic Research Association has for the past five years had a small group devoted to these studies and has been working in close co-operation with various Service departments and industrial concerns. It was felt that some attempt to set up a forum for the exchange of ideas would be timely, and the outcome was a Symposium on Special Ceramics held at the Laboratories of the British Ceramic Research Association in Stoke-on-Trent during July 13–15. About 150 delegates attended the symposium and seven countries were represented. The subject-matter of the symposium was divided into four sessions dealing with: (1) properties and structure, measurements; (2) preparation and properties of nitrides; (3) preparation and properties of other non-oxides; and (4) furnaces, techniques, analysis, applications, etc.

After a welcome to the delegates by the chairman of the Association, Mr. E. James Johnson, and the director, Dr. A. T. Green, the deputy director, Dr. N. F. Astbury, gave an introductory lecture on the fields of application for new ceramic materials, and spoke of the special ceramics research programme of the British Ceramic Research Association, in which particular reference was made to boron nitride, a machinable dielectric capable of withstanding high temperatures, and to a new form of self-bonded silicon carbide and to silicon nitride. Both the latter materials are being actively studied in connexion with rocket engineering. The dependence of macroscopic properties on crystal structure and the trends observed in groups of materials of the same structure were discussed in a paper by Dr. S. N. Ruddlesden (British Ceramic Research Association), who illustrated her arguments by non-oxides such as silicon nitride and boron phosphide, the latter being a new compound of the III–V series of zinc-blende structures. Like silicon carbide, boron phosphide is very hard and it is a semiconductor with an energy gap of the order of 5 eV.

The greatest challenge that ceramics must face in meeting metals in their chosen field is the absence of ductility and their comparatively low breaking strain. The reply to this is being sought by a study of the properties of certain oxide crystals, and it was of special interest, therefore, that Dr. F. J. P. Clarke (U.K. Atomic Energy Authority, Harwell) was able

to give an account of his experiments on the room-temperature ductility of single crystals of magnesium oxide, together with his observation of slip bands and fracture starting at the intersection of these slip bands near a crystal face. Dr. Clarke discussed possible applications of his results to polycrystalline materials.

Methods of measuring thermal conductivity requiring much less time than traditional methods were described by Mr. T. W. Lindop (Morgan Crucible Co.), and Mr. R. P. Tye (National Physical Laboratory) contributed to the discussion with an account of an even more rapid (< 1 min.) comparator method. A simple apparatus for the measurement of creep at high temperature (1,200° C.) was described in a paper by Messrs. N. L. Parr and G. F. Martin, read by Mr. D. M. Rae (Admiralty Materials Laboratory). Dr. Clarke ended the first session with a description of the effect of reactor irradiation on ceramic materials, which aroused some lively discussion on the damage mechanism and the neutron energies causing most damage.

Silicon nitride is a hard, very strong material (the modulus of rupture at 1,200° C. is of the order of 18,000 lb./sq. in.) which can be made into shapes of accurate dimensions by nitriding pressed silicon-powder, since no contraction occurs during the firing. Its preparation, its properties as an engineering material (it possesses very good thermal shock resistance and satisfactory resistance to creep) and its microstructure were described by Messrs. N. L. Parr, G. F. Martin and E. R. W. May (Admiralty Materials Laboratory). In the subsequent discussion, Mr. P. Popper (British Ceramic Research Association) showed photographs of some intriguing spiral 'whiskers' of silicon nitride. A new hexagonal form of Be_3N_2 was described by Drs. A. Rabenau and P. Eckerlin (Philips, Aachen), who had studied the system Be_3N_2—Si_3N_4 and found two other compounds, Be_4SiN_4 and a wurtzite-type compound, $BeSiN_2$.

There is a wide gap between organic plastic insulators, which can be easily shaped by moulding or machining but which cannot withstand high temperatures, and refractory insulators, which can withstand very high temperatures but are difficult to make to accurate dimensional tolerances. One material which helps to bridge this gap is boron nitride, a refractory insulator which can be easily machined, a property which is attributed to its layer lattice crystal structure, which resembles that of graphite, with which it is isosteric. It is not wetted by many molten metals and has a high electrical resistivity (10^6 ohm cm. at 1,300° C.) and high resistance to chemical attack. The preparation of boron nitride, its possible uses, the control of hot-pressing and stability by additions of 'impurities' were described by Dr. T. A. Ingles and Mr. Popper (British Ceramic Research Association). Other possible materials to bridge the gap are being sought in polymers which contain boron and nitrogen or phosphorus and nitrogen. The paper by Messrs. F. W. Ainger and I. M. Herbert (Plessey Research Laboratories) on the preparation of phosphorus–nitrogen compounds as non-porous solids was remarkable for the presentation of so much inorganic chemistry in the language of the organic chemist.

Knowledge of dissociation pressures is important in considering materials for high-temperature applications, and measurements of the dissociation pressures of metallic silicides and of silicon carbide were reported by Mr. P. Grieveson and Dr. C. B. Alcock (Imperial College of Science and Technology), who interpreted their results on a thermodynamic basis. A novel way of preparing an extremely strong, dense silicon carbide, without the need for hot-pressing, was described by Mr. P. Popper. The method involves heating a cold-pressed mixture of carbon and silicon carbide powder in an atmosphere of silicon vapour when, under appropriate conditions, a material is obtained with a density of 3·05 gm./cm.³ (corresponding to 95 per cent crystallographic density) and a modulus of rupture at room temperature of the order of 30,000 lb./sq. in. Another silicide, $MoSi_2$, described by Mr. J. B. Huffadine (Plessey Research Laboratories), has a very low electrical resistivity and is used in heating elements. It has a remarkably high oxidation resistance and an expansion coefficient substantially the same as alumina, from 0° to 1,000° C. It also adheres strongly to alumina if hot-pressed with this oxide, and it was suggested that composite $MoSi_2$—Al_2O_3 pressings could provide useful electrical components.

The preparation and properties of calcium fluoride ware were described by Mr. P. Rado (Worcester Royal Porcelain Co.). Although this material has a very poor thermal shock resistance, it has found application as a crucible material for the reduction of metallic fluorides, particularly uranium fluoride.

Photoconductive materials have normally been used in the form of single crystals, but Drs. W. van Gool and J. G. van Santen (Philips, Eindhoven) showed that a polycrystalline aggregate of cadmium sulphide could be used as an element in photosensitive devices.

Throughout the symposium attention was repeatedly directed to the high-temperature techniques required in the preparation of special ceramics, and some of these were discussed in detail in the final session, which included three papers on furnace design. Dr. A. Z. Borucka (Metals Research, Ltd.) described the construction of a furnace to give a hot zone (1,200° C.) of very uniform temperature by having the furnace windings split into several sections with the spacing of the windings graduated in each section. Dr. M. Cole and Dr. Borucka (Metals Research, Ltd.) described a novel replaceable heating element, consisting of a molybdenum heater encased in an alumina sheath through which hydrogen or another protective gas is passed. These elements can heat a furnace with a capacity of several cubic feet to 1,800° C. in either oxidizing or reducing atmospheres, giving a uniform temperature distribution with no contamination of the furnace atmosphere. The construction and advantage of various types of carbon-tube furnace, that is to say, the simple tube, the single-ended, hairpin-cut tube and the spiral-cut tube, capable of operating at temperatures above 2,000° C. *in vacuo* or in controlled atmospheres, were described by Mr. C. J. W. Baker (British Ceramic Research Association).

Many of the special ceramic materials cannot be melted under normal conditions, and so sintering cannot be used as a means of densification. The alternative technique is hot-pressing, but this has the disadvantage in general that only simple shapes can be produced without further machining. Dr. J. S. Jackson and Mr. P. F. Palmer (British Thomson-Houston Research Laboratories) described an apparatus designed for hot-pressing small specimens of refractory hard materials to high density in graphite

dies heated by passing a high current through the walls. They reported the contraction of various carbides, borides and oxides as a function of temperature, and showed that reduction of particle size reduced the temperature needed for densification.

One of the difficulties of powder aggregation is the variation in density which may occur through the compact. This difficulty can be circumvented by isostatic pressing, and the use of a reversible gel, such as a polyvinyl polymer, as a mould material giving substantially true hydrostatic pressures up to 50 tons/in.^{2} was described by Mr. T. W. Penrice (Production Tool Alloy Co.). The technique is evidently applicable to quite complicated shapes.

The analyst's outlook on the new materials was touched upon in a paper by Mr. H. Bennett (British Ceramic Research Association) on the chemical determination of nitrogen in refractory nitrides, which posed many new problems. The final paper was a description by J. Peyssou (C.S.F., France) of the possible variations of properties of ceramic articles caused by variations in firing conditions and methods of manufacture.

The symposium concluded with a tour of the laboratories of the British Ceramic Research Association. The proceedings of the symposium are to be published by Heywood and Co. as a book, "Special Ceramics", which is being edited by Mr. P. Popper.

N. F. ASTBURY

SOLID STATE PHYSICS

A CONFERENCE was held at Melbourne on "Solid State Physics" during August 17–21 under the auspices of the Australian Branch of the Institute of Physics. Grants from Australian industry, learned societies, government organizations and universities and support by the United States Government research authorities, the United Kingdom Atomic Energy Authority and the Canadian Government enabled several Americans, a Canadian and three Englishmen to attend. Other States of the Commonwealth of Australia and New Zealand were well represented.

The matter was drawn from across almost the whole range of this enormous subject, and one could hope that it might set a style of conference where the programme would be not so specialized that only a few experts could really benefit.

The programme opened with a day devoted to low-temperature properties of metals and alloys. Precision lattice parameters, superconductivity and superfluidity, dislocation-phonon scattering and electron phonon drag effects were discussed. The changes of lattice parameter in bismuth on alloying set a challenge to the theorists, and the dislocation scattering of phonons seems still to be in error by a factor assessed as between three and seventy by one speaker.

Electron field emission, low-energy sputtering, epitaxial growth and dislocation barriers at surfaces served during the next day to remind those present just how little of the surfaces of solids is understood. The afternoon and following day were devoted to plasticity studies, when softening by adiabatic heating was used to explain the serrated load extension curves of iron at temperatures immediately above the brittle fracture region, as well as for aluminium at very low temperature. The dependence on orientation of work hardening and of slip-system geography in face-centred cubic metals were presented, and it was clearly the opinion of the majority that current theories are far too simple in their outlook. The Peierls–Nabarro force, its connexion with lattice friction, and the significance of the friction term in the hardening curves formed a recurrent theme in and out of the lecture room. Preliminary results indicate that reliable twin-fault densities may be obtained from the asymmetry of Bragg peaks and this may inject a little more knowledge of the deformed state. Measurements of the mechanical properties of the alkali metals at very low temperatures, along with optical microscope studies, have confirmed the X-ray evidence of shear transformations in sodium and lithium, and have brought to light a great sensitivity to structural details in the transformation of the crystalline aggregate.

On the third day attention was swung to optical properties of solids, with papers on soft X-ray studies of the light metals, infra-red and optical absorption in ionic crystals. Dielectric properties of doped alkali halides, evidence for aggregation of F centres and new techniques and facts in luminescence studies were the subjects for the remainder of the day. The analysis of rare-earth spectra in crystals is getting steadily more detailed and very large-scale calculations are rapidly elucidating the details of interactions within the f electron-shell.

The last day saw an interesting mixture of papers: the dreadful maze into which theoretical physicists lead each other when the anharmonic terms leading to thermal expansion are studied was on show, as was the theory of zone structure in liquids. Here some progress seemed to be made for the one-dimensional model. The magnetic structure of metallic chromium and its alloys was discussed in terms of magnetic properties and neutron diffraction evidence. Then came the grand finale with one situation well on the way to elucidation and three well on the way to confusion. The ordering of α-brass at temperatures of about 135° C. has been most convincingly shown and will probably remove the few remaining anomalies in the properties of the αCu—Zn phase in this temperature region. But in copper the first annealing observed after very low-temperature bombardment now occurs at only 7° K., and the atomic processes involved get steadily more mysterious. Polycrystalline calcite or 'marble' plastically uni-axially compressed at high hydrostatic pressure, largely recovers its axial dimensions on release of the hydrostatic pressure. In lithium fluoride as well as silicon iron, plastic hardening seems to denote a drop in dislocation speed under a given stress, indicating an increase in dislocation viscosity—or is it a drop in effective stress?

It was a stimulating conference, and those from overseas were impressed to find such a wealth of first-class work, enthusiasm and hospitality in this rapidly growing and developing continent of Australia.

W. M. LOMER

UNIVERSITY GRANTS IN GREAT BRITAIN

THE annual returns from universities and colleges in receipt of Treasury grants from the academic year 1957–58, now covering twenty-one universities and three colleges, issued by the University Grants Committee, records a further increase in the number of full-time students to 95,442, compared with 89,866 in 1956–57 (Pp. 54. Cmnd. 832. London: H.M. Stationery Office, 1959. 5*s*. net). Statistics collected in October 1958 showed a university population of about 100,000, and this number is expected to reach at least 110,000 by 1961–62. There were 6,180 full-time and 2,208 part-time students from overseas within the British Commonwealth and 3,982 full-time and 1,904 part-time students from foreign countries; for 1956–57 the corresponding figures were 6,115 and 2,016 for the Commonwealth and 3,792 and 1,756 for foreign countries. Of full-time new students 36·4 per cent were in arts, 23·7 per cent in pure science, 19·0 per cent in technology and 13·7 per cent in medicine: these figures compare with 38·7, 15·2, 13·5 and 26·1, respectively, in 1938–39. For full-time women students the corresponding figures for 1957–58 are 63·5, 20·0, 0·8 and 12·1, respectively, and for 1938–39, 64·7, 15·9, 0·8 and 16·2. Full-time advanced students of pure science numbered 3,853 (34·8 per cent); of technology, 1,916 (17·3 per cent); and of medicine, 968 (8·8 per cent); 3,007 students were taking postgraduate courses in teacher training.

Of the full-time students 76,687 were reading for a first degree, 3,937 for a first diploma and 14,069 engaged in research or other advanced work, the corresponding figures for 1956–57 being 71,713, 3,969 and 13,379, respectively. Of the new full-time students, 24·0 per cent were in pure science, 15·4 per cent in technology and 9·3 per cent in medicine; for 1956–57 the corresponding figures were 23·8, 15·0 and 9·6 per cent, respectively.

The proportion of assisted students was 79·2 per cent compared with 75·7 per cent in 1956–57 and 71·9 per cent in 1953–54, ranging from 92·2 per cent in Wales, 86·7 per cent in English universities, excluding Oxford, Cambridge and London, to 67·2 per cent for Scotland. Full-time teaching and research staff increased to 10,542, compared with 10,485 in 1956–57. The proportion of full-time students residing in colleges or halls of residence was 26·4 per cent compared with 27·4 per cent in 1956–57 although the total, 25,174, was higher. The proportion of men in residence, excluding Oxford, Cambridge and London, was 22·4 per cent and of women, 38·6 per cent, whereas 46,237 (48·4 per cent) were in lodgings and 24,031 (25·2 per cent) at home, compared with 46 per cent and 26·6 per cent, respectively, the previous year.

Of the recurrent income of £49,418,302 (an increase of £7,762,693 on 1956–57) £34,953,406 was from Parliamentary grants (70·7 per cent). Income from fees increased from 11·2 per cent to 11·5 per cent, local authority grants decreased from 3·1 to 2·8 per cent, endowments from 4·0 per cent to 3·6 per cent, donations and subscriptions from 1·2 to 1·1 per cent, and payments for research (£3,008,898) from 6·5 per cent to 6·1 per cent. Non-recurrent grants in respect of capital expenditure amounted to £11,816,479 compared with £9,134,185 in 1956–57 and of the recurrent expenditure of £48,335,053—an increase of £6,825,350 on 1956–57—7·1 per cent was spent on administration, 68·6 per cent on departmental maintenance and 12·5 per cent on maintenance of premises. Expenditure on libraries increased from £1,620,958 to £1,821,943 but decreased to 3·8 per cent of the total.

NUCLEAR RESEARCH IN AUSTRALIA

IN the sixth annual report of the Australian Atomic Energy Commission (Commonwealth of Australia, 1958. Pp. 62. Sydney: Australian Atomic Energy Commission, 1959), covering the year ended June 30, 1958, considerable space is devoted to the Commission's Research Establishment at Lucas Heights, which was officially opened by the Prime Minister of Australia, the Rt. Hon. R. G. Menzies, on April 18, 1958. During the period up to the beginning of May approximately 4,500 visitors went to the Establishment. Many of the major buildings have been completed and this has enabled the research staff to return from Harwell and to begin to design and assemble equipment for their research projects. The Commonwealth Government has approved a further building programme involving an expenditure of £1·6 million during 1958–59 and 1959–60 on new laboratories and services, including engineering research laboratories, a building in which the fabrication and chemistry of beryllium fuels can be studied, and post-irradiation handling equipment.

The report details the work of the principal sections of the Establishment and the various research projects to be undertaken. The main function of the Isotopes Section is the advisory service to industry and research, and 310 requests for advice on various aspects of isotope production were dealt with during the year. Australian industry and research in comparison with the United States of America or the United Kingdom has, however, been slow to accept the use of radioisotopes. The Section assisted in a large-scale field test, in which a radioisotope technique was used to measure the efficiency of mixing in a cooling pond in an electrical power station. Other investigations included the development of a method for the continuous investigation of moisture content of brown coal; a technique for tracing sewage sludge in sea disposal; siltation in the Hunter River; and the use of radioisotope tracers in cloud physics.

A large proportion of the work of the Technical Physics Section has been concerned with the installation and commissioning of the control gear and instrumentation of the High-Flux Australian Reactor, at the Establishment. Other equipment constructed and tested include a fast scaler, using transistors, with 'plug-in' scales of ten, and a discriminator with resolving time of 1 μsec.; a beta-gamma coinci-

dence unit; and linear amplifiers and scintillation counters for the Health Physics Section.

One of the aims of the fuel element research conducted at the Establishment is to develop a 'self-breeding' fuel in which thorium is present in such quantities that fissioned uranium is continuously replaced by uranium-235. Beryllium and beryllium oxide are also being studied as moderator materials and fuel carriers. Another problem under study is the production of graphite which is impermeable to fission product gases and several methods of sealing inherent porosity are being investigated. Research on a sodium-based liquid metal fuel reactor was begun at Harwell and is being continued at Lucas Heights. The experimental assemblies built by the Australian staff while at Harwell have been purchased and shipped to Australia. The sodium plant built by the Australian Atomic Energy Commission at the Research Establishment is a research tool designed to pump molten sodium at 500° C. at 10 gall. per min. and it will provide facilities for carrying out research on compatibility problems, sodium component testing, heat-transfer investigations and the training of staff in the handling of liquid metals.

In the sections of the report dealing with the search for, and mining of, uranium details are given of the airborne radiometric and geological surveys carried out by the Bureau of Mineral Resources. There was a marked decline in interest in the search for uranium both by companies and individual prospectors. This is attributed to the uncertainty regarding the future of the world uranium market. The picture presented in the report is that of a rather difficult period in the years immediately ahead, but that the present rate of production could well prove insufficient within the next decade. The production of uranium oxide at Rum Jungle was lower than in the preceding year. Full-scale open-cut mining has been in progress at Mary Kathleen during the year and a large stock-pile of ore for treatment has been built up. A recalculation of the ore reserves of the Mary Kathleen deposit has shown that the total reserves of recoverable uranium oxide are greater than was originally thought and more than enough to complete the contract with the United Kingdom Atomic Energy Authority.

A symposium on the "Peaceful Uses of Atomic Energy in Australia" was held in Sydney during June at which 114 papers were presented. Brief details of the proceedings are given in the annual report, and a record of the papers and discussions is to be published. The publication of a new quarterly, *Atomic Energy*, giving information on developments in and applications of nuclear science and technology was commenced during the year, and the booklet entitled "Prospecting and Mining for Uranium in Australia" was reprinted. Six atomic energy exhibitions in various towns in the Commonwealth were presented by the Commission in addition to several television programmes at national and commercial stations in Sydney. The annual report concludes with a statement of the net expenditure of the Commission for the year ended June 30, 1958; details of the extra-mural research projects at various Australian universities; the names of the senior research staff and holders of the postgraduate research studentships and undergraduate scholarships; and a bibliography of the principal publications of members of the Commission, its staff and advisory committees.

CONSERVATION OF ENGLISH WALLPAINTINGS

IN recent years those interested in early wall-paintings have been greatly perturbed by their condition and the rather haphazard methods sometimes employed for their preservation. It was therefore more than timely in 1953 for the Central Council for the Care of Churches and the Society for the Protection of Ancient Buildings to appoint a committee to report on the nature and causes of the troubles which have been observed in such paintings, the remedies which could be applied and the methods which would give the best hope of successful preservative treatment in the future. The report* was compiled under the able chairmanship of Mr. W. I. Croome. The committee included well-known archæologists and scientists who had made a special study of this problem.

At the outset the committee was seriously perturbed by the use of varnish and wax as a preservative, for these act as relatively impervious skins and impede the rate of evaporation of moisture and cause disintegration of the surface. As a preliminary measure it advised that these two methods should cease immediately.

The report continues with an instructive and necessary explanation of the technical terms and materials used in wallpainting. Then follows a useful summary of English and foreign practice in relation to wallpaintings with some pregnant notes on the effect of time. These clearly show that the conservation methods used were not satisfactory.

It was therefore abundantly clear that much fundamental work was necessary and the constructive recommendations of the committee are based on the practical applications of its conclusions.

The main recommendations deprecate the use of wax varnish, sodium silicate, or ethyl silicate for any preservative treatment. The use of caesin in a maximum 2 per cent solution in appropriate cases should be confined to the binding of loose pigment. Lime water should be used for the consolidation of the plaster foundation, and in the case of disintegration of the paint it may be mixed with skim milk. The committee stresses that since wallpaintings are liable to deteriorate under conditions of damp every care should be taken to make the church structurally sound and thus exclude any excessive moisture.

The committee feels that much further research should be undertaken on this problem and suggests a course of training which will eventually provide a succession of practitioners for this important work.

The report concludes with some practical notes for the removal of wax preparations, retouching and overpainting, recording and some excellent illustrations of work that has already been undertaken.

* The Conservation of English Wallpaintings: being a Report of a Committee set up by the Central Council for the Care of Churches and the Society for the Protection of Ancient Buildings. Pp. 30+18 plates. (London: Central Council for the Care of Churches, Fulham Palace, 1959.) 7s. 6d.

KELLOGG AND NEY'S MODEL OF THE SOLAR CORONA

In an article in a recent issue of *Nature*[1], Profs. P. J. Kellogg and E. P. Ney advance an entirely new theory of the solar corona. The generally accepted explanation of the observed corona supposes that two components contribute to its light: a *K* component due to Thomson scattering of sunlight by free electrons, which is the 'true' solar corona, and an *F* component due to diffraction scattering by dust lying between the Sun and the Earth. The *F* component increases relative to the *K* component with increasing angular distance from the Sun. The new theory suggests that the corona is an assembly of charged particles trapped by the Sun's magnetic field, analogous to the Van Allen belt of particles surrounding the Earth. The contribution of the *F* component is regarded as much smaller than is currently supposed, and the continuous spectrum of the corona is thought to arise from synchrotron radiation as well as from Thomson scattering. The authors suggest that the existing observations of the corona can be at least as well described by their model as by that currently accepted.

Although the corona certainly shows puzzling features which are but imperfectly understood, the generally accepted physical description of the observed corona is less open to objection than Kellogg and Ney suppose. This does not, however, rule out the possibility of an alternative explanation such as the one they propose. We think it unfortunate that Kellogg and Ney have not compared the requirements of their theory with the most recent and reliable observations. They seem not to appreciate the care that is now taken in eclipse work to avoid errors which are known to exist in earlier observations, and have adopted uncritically those earlier observations that they have considered. In this communication we wish particularly to show that the agreement of the new theory with observation is not as good as its authors represent, rather than to criticize their theoretical reasoning.

We have space to discuss only a few of the points made by Kellogg and Ney which seem to us especially open to objection. For convenience these are taken in the order given in the original article.

Scale height of the corona. The model developed by Kellogg and Ney is suggested by the supposed similarity between the gradient of electron density in the corona (as calculated by these authors) and the gradient in the outer parts of the Van Allen belt. The electron density in the solar corona has been the subject of many careful investigations, and in modern models of the corona it is supposed that, at angular distances of the order of $5R_\odot$ from the centre of the Sun, electron scattering contributes only about 15 per cent to the brightness. However, for the purposes of their theory, Kellogg and Ney calculate the electron density assuming that *all* the light of the corona is due to electron scattering even out to $10R_\odot$. In their calculation they use a crude law $(1/R^6)$ for the variation in brightness with distance from the Sun, an approximate method for conversion to electron densities, and then plot the results incorrectly in their diagram. (According to their approximation, the electron density should vary with the linear distance $r_\odot$ from the Sun as r^{-5}: the curve shown in their Fig. 1 shows the variation as r^{-6}.) Although we shall show later that we believe it wrong to neglect the contribution of the *F* corona out to $10R_\odot$, we assume for the present with Kellogg and Ney that this is permissible. Baumbach's formula[2] for the brightness distribution fits the more modern observations (for example, those of Michard[3] and von Klüber[4]) within 10 per cent. As Baumbach was not aware of the existence of the *F* component, we may also adopt Baumbach's electron densities, which assume a pure electron corona, and these are plotted in our Fig. 1 together with the curve from Kellogg and Ney's diagram.

Comparing the two, we see that at $10r_\odot$ from the Sun, and assuming electron scattering only, Kellogg and Ney have made a total error in electron density of a factor of $\times 350$. The similarity between the Kellogg and Ney distribution and the Van Allen distribution is now almost entirely lost.

In the latter half of their article Kellogg and Ney remark that there are at least three outstanding effects which are usually ignored in explaining the solar corona, these being the degree and direction of polarization, the infra-red excess, and the variation

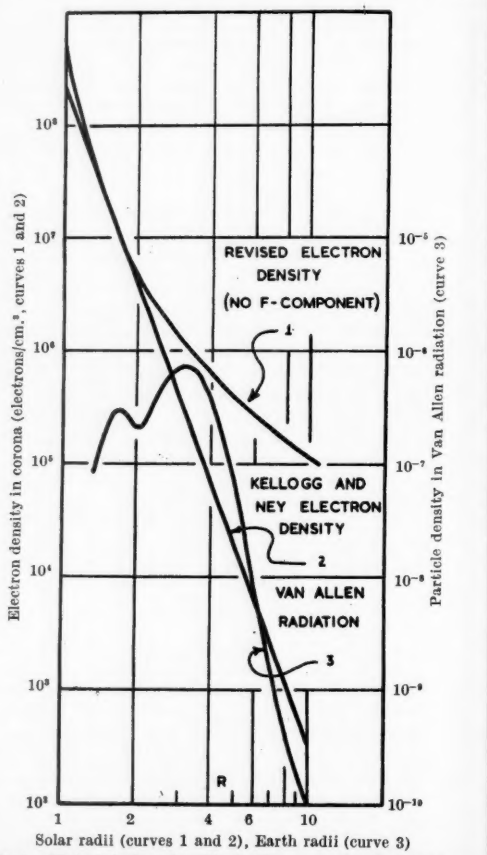

Fig. 1. Plot of electron densities in the corona as calculated by Kellogg and Ney (curve 2) and revised by the present authors (curve 1) on the assumption of pure electron scattering, together with the particle densities in the Van Allen radiation (cf. Fig. 1 of ref. 1).

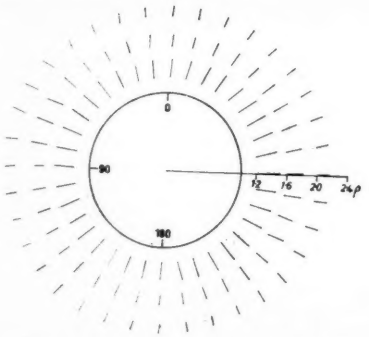

Fig. 2. Direction of polarization (magnetic vector) of the coronal light observed by von Klüber at the 1952 eclipse (ref. 4)

with phase in the sunspot cycle. This statement is not correct; at least the first two of the effects mentioned are an important part of the conventional theory.

Polarization of the coronal light. Kellogg and Ney's second argument concerns the direction of the plane of polarization of the coronal light. If the coronal light is merely sunlight which has been scattered by electrons or dust, or both, it must be partially polarized with the magnetic vector lying in a radial direction. If, on the other hand, part at least of the light is synchrotron radiation, deviations from the radial direction would be expected which would depend upon the variation of strength and direction of the magnetic field along the line of sight. As the authors remark, the measurement of direction of polarization is a very important one. At the same time it is a very difficult one, and it is only in the last decade that the nature of the difficulties has been understood. The sky background is strongly polarized, and except near the solar limb has an intensity comparable with that of the corona. Most of the early observations of polarization were inadequately corrected for the sky background, even if the photometric procedures were adequate in the first instance, and should therefore be rejected. The first author to correct for the polarization of the sky background was Öhman[5], who concluded from a careful analysis of his observations of the 1945 eclipse that the polarization of the corona at 5000 A. was radial at all points examined. Reliable measurements were also made by von Klüber[4] at a wave-length of 4300 A. during the 1952 eclipse; his results are shown in Fig. 2.

Von Klüber considers that almost all deviations from the radial direction may be attributed to observational error.

We now consider briefly the older observations quoted by Kellogg and Ney. Zakharin's observations gave deviations of up to 80°, but Zakharin admits that the plates seem to be of very poor quality[6]. Richtmeyer and Schmidt found an average deviation in three streamers of 9° and a maximum deviation of 17°; the original plates taken by Richtmeyer are of "moderate photometric quality" with irregular plate fog[7]. Saito's results[8], not available to Kellogg and Ney, relate to the inner corona (there are only a few measurements beyond 6′); the deviations from radial polarization are all less than 15° and 80 per cent of the measured deviations are less than 7°. It is worth commenting that the method usually used to determine the plane of polarization, namely, comparison of three simultaneous photographs, can easily lead to considerable error, especially in parts of the corona where there are large brightness gradients. Summarizing, the best recent measurements do not support the large departures from radial polarization indicated by the two diagrams of Kellogg and Ney's paper.

The degree of polarization is not considered by Kellogg and Ney. For Thomson scattering the polarization can be computed once the distribution of electron density is known. However, the computed electron density depends upon whether we assume that all the light is due to electron scattering, or whether part of it is due to either dust scattering or synchrotron radiation. We therefore give in Fig. 3 two curves showing the computed polarization of the electron component only. Curve *A* is taken from von Klüber's work and is computed from the electron densities appropriate to a conventional model; curve *B* is taken from Baumbach's work and is computed assuming that all the light of the corona is due to electron scattering. It is evident that the computed polarizations of the electron component do not depend critically on the form of the distribution of electron density. Curve *C* shows the actual polarization observed by von Klüber in the equatorial regions. The reasonable agreement in the region close to the Sun ($1{\cdot}0R_{\odot}$–$1{\cdot}5R_{\odot}$) supports the electron scattering theory. Farther from the Sun the observed polarization becomes progressively smaller than that required for a pure electron scattering model; the explanation for this in terms of *F* and *K* components is that the part scattered by electrons is being diluted by an unpolarized component due to scattering by dust. This seems a quite satisfactory explanation which is quantitatively supported by other evidence (for example, the observed equivalent widths of Fraunhofer lines) which we do not consider here.

The infra-red excess of the corona. The colour and infra-red excess of the corona have also been the

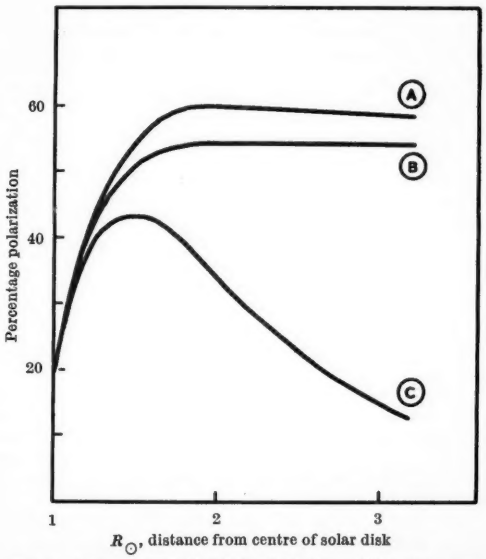

Fig. 3. Observed and calculated polarizations of the solar corona, and their variation with distance from the solar limb. Curve (*A*) polarization of *K* component only computed by von Klüber for his electron density distribution, (*B*) polarization computed by Baumbach, (*C*) actual polarization observed by von Klüber

subject of recent investigations. Briefly, the results are that close to the Sun the colour is not significantly different from that of the average solar disk[9], but in the outer parts the infra-red excess becomes appreciable; at a distance of $2 \cdot 5 R_{\odot}$ and at a wave-length of $1 \cdot 9 \mu$ it has been measured to be 2·17. Such an excess is naturally explained by the diffraction theory of the F corona[10]. That there is dust in the solar system is shown by the existence of the zodiacal light, and both van de Hulst[11] and Allen[12] have shown independently that both the F corona and the zodiacal light can be explained by a single model for the interplanetary dust. The variation in infra-red excess mentioned by Kellogg and Ney is again accounted for by a varying ratio of electron component (with colour identical with that of the Sun) and dust component (which shows an infra-red excess).

We may remark here that after allowing for the dust corona in the conventional model the true electron densities in the outer solar atmosphere are considerably lower than indicated by the Baumbach curve in our Fig. 1, and in fact are in rather better agreement with Kellogg and Ney's curve—but not for the reason these authors suggest. However, at $10 r_{\odot}$ there still remains a discrepancy of about $\times 40$ between the true electron density and the lower value given by Kellogg and Ney.

There is a contradiction here that is not satisfactorily explained by these authors in their article. If the conventional electron densities, or particularly Kellogg and Ney's densities, are accepted, the computed brightness at large distances from the Sun is much smaller than the observed brightness. In conventional theory the extra light arises from dust scattering, but Kellogg and Ney attribute it to synchrotron radiation. If this attribution is correct, synchrotron radiation must increase in importance with increasing distance from the Sun—and indeed we have shown that the infra-red excess increases in the outer corona. But synchrotron radiation does not explain the existence of unbroadened Fraunhofer lines in these parts of the corona, although these lines are satisfactorily explained in terms of scattering by interplanetary dust particles far from the Sun.

We shall not detail other criticisms which we feel could be made, but mention one last observational point. Kellogg and Ney propose that if the solar corona is really analogous to the Van Allen particle belt, one might expect a maximum in the coronal intensity close to the Sun. They believe that such a maximum might exist, supposing that "the problem of reversal in photographic emulsions has previously masked the possible presence of a maximum". So gross an effect as photographic reversal has not complicated the interpretation of eclipse photographs in any competent observations made since the 1890's. There are in fact other much more subtle sources of error in the photometry of such a difficult object as the solar corona, and these errors may more readily be overlooked in photoelectric than in photographic photometry. The most careful work in this region has never shown a maximum of the kind suggested by Kellogg and Ney, and its existence is very doubtful.

We agree with Kellogg and Ney that further observations of the polarization over a greater range of wave-lengths are required and should be made at future eclipses. Also, it is unfortunate that the most reliable measurements of polarization, and to some extent of infra-red excess, have been made near sunspot minimum; repetitions near maximum would be of value.

However, we are of the opinion that the authors have not substantiated their claim that this interesting new theory accounts better for the observed properties of the corona. While it may be that synchrotron radiation is a third contributor to the coronal light, we do not think the present observations support the postulate that sufficient synchrotron radiation exists to justify a major modification to the present two-component model of the corona.

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We wish to express our appreciation for the critical comments made by Drs. Blackwell and Dewhirst concerning our suggestions about the nature of the solar corona. We are not professional astronomers and for this reason we may have placed undue emphasis on certain published literature, with perhaps too little emphasis on other literature more generally accepted by astronomers. We do feel, in spite of the remarks of Drs. Blackwell and Dewhirst, that under each of the topics which were discussed in our original article, experimental evidence exists which makes the possibility of synchrotron radiation from a magnetically contained corona at least a very plausible hypothesis.

The principal objection of Drs. Blackwell and Dewhirst seems to rest on a question of terminology. To us, the F corona is not a real part of the corona, but represents a spurious effect which must be removed. In the interests of brevity, we omitted any mention of the experimental difficulty of separating the F-coronal light from that of the electron corona, except for one or two comments, but we are aware of at least part of the evidence for the existence of the F corona. Thus the curve which we marked curve 1 in our Fig. 1 is supposed to represent the electron density and not the total coronal light. It was plotted as $1/R^6$ not by mistake, as Blackwell and Dewhirst imply, but to represent the currently accepted electron densities. Eclipses subsequent to the one observed by Turner have led to electron densities falling off as $1/R^6$ instead of $1/R^5$, as would have been obtained from the 1898 eclipse alone. In order to obtain electron densities at large distances, the F corona must of course be removed. Considering the rough nature of the ideas involved and the difficulties of measurement, we consider that the result is in reasonable agreement with our curve. We pointed out the similarity of the solar corona and the radiation belt to indicate the attractiveness of confining charged particles by a magnetic field, in contrast to a gravitationally confined atmosphere. The comparison with the Van Allen radiation is intended only to be suggestive, and obviously no

very close agreement is to be expected. However, the most recent observation of the radiation belt by the Iowa group shows even better agreement with the coronal curve 1 than the results shown in curve 3 of our original article.

It is unfortunately true that the measurements of Zakharin were made with some instrumental difficulties and the resulting plates were not of the highest quality. Nevertheless, these and the other measurements quoted by us remain the only measurements of the direction of polarization of the coronal light which were made near sunspot maximum. It seems very likely that synchrotron radiation will be observed only near solar maximum. Again, Nikonov's measurements of the infra-red excess were probably not as well done as the measurements by Blackwell in the 1952 eclipse. Nevertheless, as they stand, they do not agree with the idea that the infra-red excess is due to the scattering by dust, since Nikonov observed that the infra-red excess was greatest at sunspot maximum when the electron density in the corona is greatest, and therefore the relative contribution of the F corona should be least. So long as there are no more modern experiments to replace this Russian work, the answer to the questions which we are discussing must remain in doubt.

In defence of our basic idea, we believe that Drs. Blackwell and Dewhirst have taken too seriously the details of our suggestion but have tended to overlook or misunderstand the main features of a trapped corona. Our concept is that magnetic fields anchored at the surface can act as guiding centres for particles which may then be confined between mirror points, as they are in fact in the Earth's magnetic field. We accept as a working hypothesis that magnetic fields exist in the region of the solar corona. We also believe, because of cosmic-ray evidence, that the Sun is able to inject high-energy particles into these magnetic fields. If high-energy electrons are injected into magnetic fields, then synchrotron radiation will automatically occur. In fact, if the corona were examined in light of long enough wave-length, the synchrotron radiation would necessarily be observable. We wish to emphasize the point, which was made in our article, that the extent of the trapping of particles in the corona may depend strongly on solar activity, and therefore polarization and infra-red excess measurements made at sunspot minimum are definitely not evidence against our suggestions.

Perhaps the title of our paper, "A New Theory of the Solar Corona", was too ambitious, since our model requires so many of the constituents of the description of the corona currently accepted. The comments made by Drs. Blackwell and Dewhirst seem to indicate that they believe we would reject the description of the corona in terms of K and F corona. This is not correct; we certainly believe that the majority of the visible light from the inner corona is produced by Thomson scattering by slowly moving electrons, and it is almost impossible to escape the conclusion that the outer corona must be largely composed of dust grains, as has been very effectively discussed previously by Dr. Blackwell. We feel, however, that ultimately some experiment will reveal the existence of trapped particles, and that it is possible that this experiment may consist of measuring in redder and redder light the polarization of the corona at times of high solar activity. Should the experiments in the visible or near infra-red reveal synchrotron radiation, our postulate of the magnetically trapped corona would be confirmed. However, we do not believe that the absence of synchrotron radiation at visible wave-lengths would disprove our hypothesis. Our calculations show that in order to see synchrotron radiation in the visible region of the spectrum, an integral energy spectrum for trapped particles would be required that goes at least as slowly with energy as $1/E$. An energy spectrum which falls as steeply as $1/E^2$ would not produce synchrotron radiation in the visible region in great enough intensity to be seen against the background of the Thomson scattered light.

The reason for presenting our article in *Nature* was that a study of the literature to which we referred had in fact convinced us that enough doubt existed as to the coronal polarization to justify an intensive experimental study of the problem at sunspot maximum. In the months that have followed since its submission, we have designed and constructed electronic telescopes which use photomultiplier detectors and television raster scanning to measure the polarization out to three solar radii in a pattern consisting of approximately 900 individual points. The polarization will be measured in fixed positions in the corona and the scan will proceed from one position to the next until the entire area is covered. This method eliminates many of the inherent difficulties involved in photometric measurements of coronal polarization. The equipment which we have designed is to carry out the programme just described six times during the total eclipse of October 2, 1959, and we therefore hope that, cloud-cover permitting, we will be able to contribute some useful results on this rather important problem.

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PROTON RESONANCE RELAXATION TIMES IN MOBILE LIQUIDS

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We have measured the proton magnetic resonance relaxation times, T_1 at 250 ± 25 gauss and at 5,000 gauss and T_2 at 0·75 gauss, for a number of organic liquids and solutions at 25° C. The results are summarized in Table 1.

Although T_1 and T_2 have not been measured at the same field and so are not strictly comparable, the results suggest that T_2 may be appreciably shorter than T_1. The difference is most striking for the benzene solutions. Some examples in which $T_1 = T_2$ have been observed, and also cases where more than one chemical type of proton is present have been studied[1,2].

Both T_1 and T_2 are strikingly shorter in fluorobenzene than in any of the other substituted benzenes. The short T_2 is implicit in the results of Elliott and

Table 1. Values of T_1 and T_2 in Sec. for Various Organic Liquids and Solutions at Various Fields and at 25° C.

Liquid	$T_2 \pm 10$ per cent at 0·75 gauss	$T_1 \pm 10$ per cent at 250 ± 25 gauss	$T_1 \pm 5$ per cent at 5,000 gauss	Literature values of T_1† (in sec.)	at field (in gauss)	Literature values of T_2† (in sec.)	at field (in gauss)
Water (H_2O)	2·7	3·6	3·6	3·4 (*a*)	2,000 and 7,000	2·7 (*d*) (temperature	7,000 not stated)
				3·5 (*b*)	1,650		
				3·4 (*g*)	7,000	3·0 (*e*)	0·5
*Cyclo*hexane (C_6H_{12})	3·5	5·5	7·1	6·5 (*b*)	1,650	—	—
Benzene (C_6H_6)	11	18	—	19·3 (*c*)	9,500	17 (*e*)	0·5
				19·0 (*b*)	1,650	10 (*d*)	7,000
Nitrobenzene ($C_6H_5NO_2$)	3·3	6·7	7·9	6·5 (*b*)	1,650	—	—
Chlorobenzene (C_6H_5Cl)	7·0	12·5	—	15 (*b*)	1,650	—	—
Bromobenzene (C_6H_5Br)	4·0	7·0	14·0			—	—
Fluorobenzene (C_6H_5F)	0·7 ± 0·2	0·7 ± 0·2	—	—	—	0·4 (*f*)	0·5
73·1 per cent C_6H_6* in CS_2	3·0	17·5	—	—	—	—	—
40·5 per cent C_6H_6 in CS_2	5·5	24	—	—	—	—	—
71·7 per cent C_6H_6 in CCl_4	6·0	16	—	—	—	—	—
42·0 per cent C_6H_6 in CCl_4	8·0	28	—	—	—	—	—

* Molecular

† Corrected to 25° C. using viscosity if at slightly different temperature.

References for literature values in Table 1. (*a*) = 17; (*b*) = 18; (*c*) = 4; (*d*) = 8; (*e*) = 7; (*f*) = 3; (*g*) = 19.

Shumacher[3] at 0·55 gauss, although they do not claim to have measured a value of T_2.

T_1 for the benzene solutions rises with dilution and would probably reach the value of $T_1 = 60$ sec. observed by Nederbragt and Reilly[4] at 9,500 gauss for 8 per cent benzene in carbon disulphide measured by the recovery from saturation. This emphasizes the anomalous nature of the T_2 values.

The measurement of T_1 at any field-strength is straightforward. Measurement of T_2 is much more difficult and values of T_2 in excess of about 1 sec. require special care. We have taken considerable pains to ensure a true measure of T_2, as has been briefly described[5], and which will be discussed in detail elsewhere[2].

For water a difference between T_1 and T_2 at 7,400 gauss has been reported[6] but the sample evidently contained dissolved oxygen and so the values are not strictly relevant. The value of T_1 is well established and appears to be independent of the field. A value of T_2 of 3·0 sec. has been reported[7] and a value of 2·7 sec. is implicit in the measurement of Meiboom and Gill[8] at 7,000 gauss. Another result[9] appears to be T_2 in presence of a radio-frequency field.

For benzene the value of T_1 of about 18 sec. is well supported and is independent of the field. A T_2 value of 16 ± 3 sec. at 20° C. and 0·5 gauss is reported from direct measurement of line-width[7]. A reported value[10] of T_2 of 18·5 sec., at 2,000 gauss, was measured in the presence of the radio-frequency field, and theory[11,12] indicates that this T_2 should have the same numerical value as T_1, as observed. We note an apparent dependence of the field of T_1 in bromobenzene and possibly in *cyclo*hexane.

Although the difference of T_1 and T_2 is most striking for the longer relaxation times, it is more realistic to consider the quantity $(1/T_2) - (1/T_1)$. This is of order of magnitude 0·1 sec.$^{-1}$. If the relaxation times are shorter than about 1 sec., such a difference is difficult to observe[1].

Current theories of nuclear resonance relaxation[13,14,20] indicate $T_1 = T_2$ for these materials, since the molecular correlation time, τ_c, is of order 10^{-11} sec. and the highest resonance frequency, ω_r, is of order 10^8 r/s. so that $\omega_r\tau_c \ll 1$. A difference only arises for slow interactions, that is, $\omega_r\tau_c > 1$, and then it is usually very dependent on the field.

The magnitude of the difference could be explained by the static interaction of any given proton with *one* other proton at about 300 A. (about 50 molecular diameters); but since we have observed exponential decays, a substantial static interaction contribution is excluded. This led us to consider the possibility that the difference could arise from interactions with distant protons which although weak, because of the factor r^{-6}, are numerous. However, calculations in which the motional effects were allowed for, using the self-diffusion equation, showed that the effect is too small. (We are grateful to Mr. D. P. Rooke for assistance with these calculations.) Most other known interactions make equal contributions to T_1 and T_2; for example, direct dipolar, anisotropic chemical shift, anisotropic indirect interaction and paramagnetic ions in low enough concentration. The difference of T_1 and T_2 for water has been explained[6] in terms of the slow fluctuating field produced as a result of proton-exchange processes. However, this effect should be proportional to the square of the field and it can scarcely explain benzene, *cyclo*hexane, etc. The only moderately plausible general explanation we have found is that of a fluctuating isotropic indirect spin–spin (J type) interaction. A constant J interaction does not cause line-splitting (except in fluorobenzene) because the protons are equivalent[15]. However, if this coupling is explicitly dependent upon time, it becomes observable because the Gutowsky, McCall, Slichter[15] theorem is no longer valid. It contributes to T_2 but not to T_1. A similar but not identical effect is found in liquid hydrogen fluoride[16]. However, in order to produce $(1/T_2) - (1/T_1) \simeq 0{\cdot}1$ sec.$^{-1}$ with $J \simeq 10$ c./s., the coupling must be interrupted at about 10^5 times per sec. This might be brought about by relatively infrequent 'violent' collisions between molecules. Proton exchange is in this sense a violent collision. The large effect in the benzene solutions would then be occasioned by the large electric fields produced by the polar solvent molecules. However, interruption of J at this rate is unlikely, except in dissociating molecules, because J-type splitting of tens of cycles per second between inequivalent nuclei is observed in molecules in similar circumstances.

Other experimental results on molecules containing more than one chemical type of proton will be discussed elsewhere[2].

The measurements of T_1 at 5,000 gauss were made by Mr. A. Hartland.

Note added in proof. A recent report[21] of measurements at 6,500 gauss shows precise agreement

with our measurements for water but $T_1 \simeq T_2$ for benzene. The explanation of the difference between T_1 and T_2 for water in terms of surface effects in the small sample seems scarcely applicable to our sample of 200 ml.

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POSSIBLE MECHANISM OF CYSTEINE PROTECTION AGAINST RADIATION CATARACT

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AND

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EXPERIMENTS have shown that cysteine injected into an animal shortly before the eye is irradiated will largely prevent development of radiation cataract. von Sallmann, Munoz and Barr[1] compared the histology of the lens epithelium in rabbits irradiated with or without a previous injection of cysteine and tentatively concluded that initial inhibition of mitosis by X-ray was unaffected, but that the number of nuclear fragments that developed after irradiation was smaller in the cysteine-treated lens. von Sallmann *et al.* used a dose of 1,500 r. and it seemed possible that it might be easier to show histologically that cysteine affected radiation damage if the dose were nearer the threshold for mitotic inhibition. We have therefore examined the effect of a pre-irradiation injection of cysteine on the mitotic inhibition, the subsequent mitotic overshoot and on the production of fragmented nuclei in the lens epithelium of rabbits using a dose of 500 r. to the right eye. The methods described by Pirie and Drance[2] were used. Comparisons were made between litter mates and between right (irradiated) and left (not irradiated) lenses of the same rabbit. These experiments have confirmed von Sallmann's earlier results. The inhibition of mitosis is as great and even more prolonged after cysteine injection followed by X-irradiation than after X-irradiation alone. The lens epithelium of the cysteine-treated rabbit shows no excess mitosis after inhibition has worn off. In two experiments a dose of 300 r. was given and again cysteine treatment did not prevent complete mitotic arrest at 24 hr. Fig. 1 shows that at all stages examined (2–28 days after X-ray) fewer fragmented nuclei were present in the lens epithelium of the cysteine-injected rabbit than in that of the animal irradiated without cysteine treatment.

But we noticed that in the cysteine-injected rabbits the epithelium of the lens of the left, non-irradiated eye also showed an inhibition of mitosis. This inhibition could be estimated through a comparison with the non-irradiated left eye of a litter mate not injected with cysteine. In order to determine the degree and duration of this inhibition of cell division by cysteine a series of experiments was done in which one rabbit received an injection of cysteine and a litter mate was used as a control, no radiation being given to either. Such pairs of rabbits were killed at intervals after the cysteine injection to one of the rabbits and comparisons made of epithelial

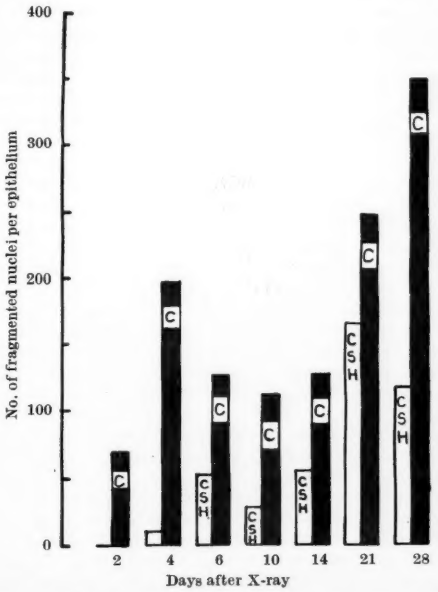


Fig. 1. Effect of cysteine injection on the development of fragmented nuclei in the lens epithelium after X-irradiation

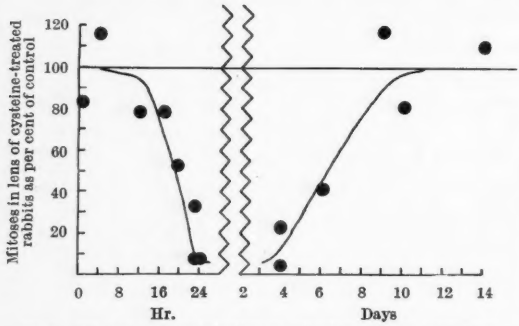


Fig. 2. Effect of cysteine injection on mitosis in the lens epithelium

histology. Fig. 2 shows that cysteine injection arrests mitosis in the lens epithelium from 24 hr. to 4 days. This inhibition of cell division then gradually wears off without any subsequent excess of dividing cells or formation of fragmented nuclei or abnormal forms up to 28 days after cysteine injection.

von Sallmann *et al.*[1] had previously found in two rabbits that mitosis was normal 2 hr. and 8 hr. after injection of cysteine. We examined lenses, 30 min., 4, 12 and 16 hr. after cysteine and found mitosis only slightly if at all depressed at these times. The total number of dividing cells and the proportion in prophase and succeeding phases of mitosis were unchanged compared with the control lenses. But at 20 hr. mitosis was only 53 per cent of the control and at 23 hr. it had fallen in one rabbit to 32 and in another to 8 per cent.

1 gm./kgm. is a very large dose of cysteine and was used only because this dose has been shown to prevent irradiation cataract. For injection, cysteine hydrochloride was, in most experiments, neutralized with sodium hydroxide and injected, in a total volume of 5–8 ml., into the ear vein of the unanæsthetized rabbit. It was noticed that the animals became almost immediately quiet, and in some cases their hind legs became inco-ordinated and they did not feed for some hours. Controls injected with an equivalent amount of sodium chloride or 1 gm. glycine per kgm. did not show these signs, nor was there a fall in the mitoses of the lens epithelium. In one experiment the cysteine hydrochloride was neutralized by shaking with 'Dowex-1'-bicarbonate resin, and the carbon dioxide blown off by passing nitrogen through the solution, thus avoiding the presence of sodium chloride in the solution to be injected. The rabbits injected with this solution of cysteine showed the same signs of inco-ordination as those injected with cysteine neutralized with sodium hydroxide and the fall in mitosis in the lens epithelium was also apparent.

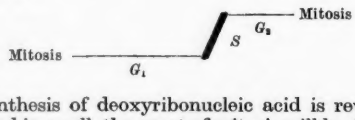
The question arises whether mitotic arrest by cysteine is related to its protective effect against X-ray damage to the lens. von Sallmann, Dische, Ehrlich and Munoz[3] found that cysteine and cystine reached a maximum in the aqueous humour about 1 hr. after intravenous injection. After a dose of 2 gm. cysteine to an adult rabbit a concentration of 40 mgm. cysteine/100 ml. aqueous humour (3 m*M*) was reached. The concentration of cystine was about the same; both gradually declined over the next few hours. Protection of the lens against radiation is effective 30 min. after cysteine injection and, in spite of the fact that mitotic arrest cannot be demonstrated for at least 19 hr. after cysteine injection, it seems reasonable to consider that the reaction(s) between cysteine or cystine and cell constituent(s) which leads to mitotic arrest must take place shortly after injection when cysteine and cystine are present in the aqueous humour. von Sallmann *et al.*[1] consider that mitosis in the lens epithelium may take only 30 min., but interphase must be prolonged, probably taking several days as in corneal epithelium (Friedenwald and Sigelman[4]). If cysteine interrupted some process early in interphase, all cells already past that point in the mitotic cycle could divide normally before any mitotic arrest became apparent. This could explain the slow development of mitotic inhibition by cysteine.

The effect of cysteine on synthesis of deoxyribonucleic acid was investigated in human bone marrow cells *in vitro* by measuring the incorporation of formate labelled with carbon-14 or thymidine labelled with tritium into deoxyribonucleic acid[5,6].

Cysteine, in a concentration of 1 m*M*, produced a 60–80 per cent depression of synthesis of deoxyribonucleic acid as indicated by grain counting on autoradiographs; a concentration of 0·1 m*M* also produced a significant depression, ranging from 30 to 50 per cent.

The concentration used in the rabbits was 1 gm./kgm., which corresponds to a concentration of about 10 m*M* in the whole animal, the concentration in the aqueous humour being of the order of 1 m*M* (von Sallmann *et al.*[3]).

The following is a scheme of the intermitotic cycle where S is the period of synthesis of deoxyribonucleic acid, G_1 and G_2 are pre- and post-synthetic gaps respectively.

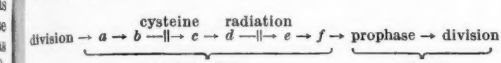


If synthesis of deoxyribonucleic acid is reversibly depressed in a cell, the onset of mitosis will be delayed. If the G_2 period is not affected then the delay in mitosis will appear only after a certain period, that is, cells already in G_2 period can proceed normally and enter mitosis, but the 'feed' of cells into the G_1 period will be depressed if the S period is elongated. The findings on mitotic counts in lens epithelium indicate that this, in fact, may be the case: the depression in mitosis by cysteine is observed only after a certain period (presumably corresponding to the length of G_2 period in these cells).

It is not known at this stage whether processes in the G_1 period are affected by cysteine or not. It is unlikely, however, that such concentrations of cysteine would affect synthesis of deoxyribonucleic acid only—nuclear phosphorylation is known to be affected by large doses of cysteine (Stocken and Creasey, personal communication), and Mazia[7] has shown that mercaptoethanol will inhibit division of the fertilized egg of the sand dollar; he suggests this is due to a reaction between mercaptoethanol and the protein which forms the mitotic spindle. He considers that formation of the fibrous spindle requires S—S links between protein molecules and that mercaptoethanol prevents their formation by competing with the available SS or SH groups.

If the process in interphase which is interrupted by cysteine lies earlier than the process which is radiosensitive, then so long as arrest by cysteine is reversible, one can postulate that cysteine protection is

related to its ability to arrest mitosis. Such protection can never be complete, as some cells will be in a stage of the mitotic cycle that is insensitive to cysteine but is radiosensitive. Cysteine protection against radiation cataract has in fact never been found to be complete.



The above scheme suggests a possible mechanism, but there is no evidence that this is a correct hypothesis, and the possibility of enhanced recovery phenomena in cysteine-treated cells should also be borne in mind. At present there is only the observation that cysteine arrests cell division in the lens epithelium of the rabbit and that if given before irradiation the number of fragmented nuclei that develop afterwards is reduced. Previous work has shown that cysteine largely protects from X-ray cataract.

Thanks are due to the Medical Research Council and to the National Council to Combat Blindness Inc., New York, for expenses grants, and to Mrs. M. Overall for skilled technical assistance.

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RELEASE OF ADENOSINE TRIPHOSPHATE AND SEROTONIN FROM INJURED CELLULAR BLOOD ELEMENTS IN EXTRACORPOREAL CIRCUITS

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CORPUSCULAR blood trauma, especially red cell and platelet damage, is still a problem inherent to extracorporeal circulatory systems, including the heart–lung machines[1,2]. Hæmolysed blood has been reported to possess vasodilator properties attributed to the release of adenosine triphosphate and/or closely related compounds from injured red cells[3]. Platelets, in turn, are known to contain large amounts of 5-hydroxytryptamine (serotonin)[4], a biogenic amine with powerful vasoactive, bronchomotor and other effects[5]. In consequence, the question arose whether these humorally acting agents would be released into plasma in extracorporeal blood circuits and whether the resultant humoral pathological blood changes would serve as a guide for disentangling the mechanisms of some complications associated with the use of heart–lung machines for open cardiac surgery.

As a tentative approach to the problem an arteriovenous (femoral artery–superficial jugular vein) shunt, consisting of a polythene tube 1 m. long, was created in four dogs and five rabbits pretreated with subcutaneous pethidine hydrochloride (2 mgm./kgm.) and anæsthetized with intravenous sodium pentobarbitone (30 mgm./kgm.). To mimic the blood trauma in the current heart–lung machines with greater surface area, pumps and filters, the inner surface of the shunts was intentionally 'cleaned' with steel-wool. Just prior to opening of the shunt the animals were heparinized (5 mgm./kgm.). In the period of extracorporeal circulation via the shunt the corpuscular blood changes and the whole blood- and plasma-levels of adenosine triphosphate and 5-hydroxytryptamine were observed. For that purpose three blood samples of about 4 ml. were taken with a siliconized syringe needle from a rubber tube incorporated to the shunts. The first blood sample was taken immediately after opening of the shunt and the subsequent samples 30 and 90 min. later. The corpuscular blood changes were determined by using routine techniques. The whole blood- and plasma-levels of adenosine triphosphate were determined by the colorimetric micromethod of Rehell *et al.*[6]. The 5-hydroxytryptamine content of whole blood and plasma was, after overnight extraction in cold acetone (4° C.), assayed by the method of Erspamer[7] based on the contraction of œstrous virgin rat uterus. The urinary excretion of this substance and 5-hydroxyindoleacetic acid (the main excretory product of 5-hydroxytryptamine) was studied in dogs only. The urinary bladder was catheterized immediately after induction of anæsthesia. Then the urine excreted before (45 or 90 min.) and during (90 min.) extracorporeal circulation was collected, measured for volume and analysed for 5-hydroxytryptamine and 5-hydroxyindoleacetic acid. The former was assayed by the same technique as that in blood and plasma, the latter according to the spectrophotometric method described by Udenfriend and associates[8].

No major alterations were found in the whole-blood adenosine triphosphate during extracorporeal circulation. This was particularly true for dogs, while in rabbits some decrease in the whole-blood adenosine triphosphate became evident. The erythrocyte count and the hæmatocrit values, correspondingly, remained substantially unaltered in dogs, while in rabbits there was some decrease in the erythrocyte count and hæmatocrit values. At the start of extracorporeal circulation no adenosine triphosphate was detected in the plasma of either rabbits or dogs. In both rabbits and dogs, however, increasing amounts of adenosine triphosphate appeared in the plasma during extracorporeal circula-

tion, the rising trend being more pronounced in rabbits than in dogs (as terminal phosphate-P ; from zero to an average of 0·9 mgm./100 ml. and from zero to an average of 0·35 mgm./100 ml., respectively). We had the impression that the degree of hæmolysis, estimated visually from the colour of the plasma in the successive samples, paralleled the changes in the adenosine triphosphate of the plasma ; with increasing hæmolysis more adenosine triphosphate was detected in the plasma. The whole-blood 5-hydroxytryptamine generally showed a clear-cut trend to decrease during extracorporeal circulation in both rabbits and dogs. Concomitantly the platelet counts fell, while the plasma 5-hydroxytryptamine levels were increased. Again, the drop in the platelet count was more pronounced in rabbits than in dogs (on the average from 318,000 to 71,000/cu.mm. and from 329,000 to 249,000/cu.mm., respectively). The same held for the fall in the total white cell count observed in both rabbits and dogs. In contrast to the plasma adenosine triphosphate, considerable activity of 5-hydroxytryptamine was found in the plasma at the start of extracorporeal circulation (average 0·2 μgm./ml. in rabbits and 0·025 μgm./ml. in dogs). In rabbits the levels of plasma then steadily increased during extracorporeal circulation (up to an average of 0·38 μgm./ml.). In dogs the plasma 5-hydroxytryptamine increased in the early period of extracorporeal circulation (on the average from 0·025 μgm./ml. to 0·045 μgm./ml.) ; but towards the end of extracorporeal circulation 5-hydroxytryptamine of the plasma showed some tendency to fall. The urinary excretion of 5-hydroxytryptamine in dogs prior to extracorporeal circulation averaged 0·002 μgm./min. In two of the four dogs there was actually no activity of 5-hydroxytryptamine in the urine before extracorporeal circulation. In the urine collected during the period of this circulation the activity of 5-hydroxytryptamine was consistently increased ; the urinary excretion of 5-hydroxytryptamine attained an average level of 0·005 μgm./min. Reverse changes were noted in the urinary excretion of 5-hydroxyindoleacetic acid ; this fell from an average of 0·78 μgm./min. before extracorporeal circulation to an average of 0·38 μgm./min. during this circulation.

Adenosine compounds are presumably liberated from all injured tissues. Platelets, for example, are rich not only in 5-hydroxytryptamine but also contain appreciable amounts of adenosine triphosphate[9]. However, proceeding from the knowledge that red cells are particularly rich in adenosine compounds, including the phosphate[3,6], that they are susceptible to mechanical trauma[3] and that their total mass in the circulatory system is enormously greater than that of the other cellular blood constituents, it is obvious that the red cells were the main source of the adenosine triphosphate released into the plasma in the present experiments. According to Udenfriend and Weissbach[4], platelets contain all the 5-hydroxytryptamine present in the whole-blood, while none is found in the plasma. Yet we found considerable activity of 5-hydroxytryptamine in the plasma already at the start of extracorporeal circulation. This may be explained by the fact that after short centrifugation at low running rates, as used to avoid hæmolysis in the present experiments (for 10 min. at 2,000 r.p.m.), the plasma still contains platelets[10]. Nevertheless, the gradually increasing levels of plasma 5-hydroxytryptamine during extracorporeal circulation, with an associated fall in the platelet counts, indicate that 5-hydroxytryptamine was steadily liberated from disintegrated platelets. The consistently increased urinary excretion of 5-hydroxytryptamine during extracorporeal circulation further indicates that 5-hydroxytryptamine was actually released into the plasma in the period of this circulation, for increased urinary excretion of 5-hydroxytryptamine has been observed after administration of exogenous 5-hydroxytryptamine[11]. Finally, the definitely higher levels of whole-blood (and plasma) 5-hydroxytryptamine in our rabbits as compared with those in dogs, the platelet counts being equal, are in agreement with the figures for 5-hydroxytryptamine content of platelets in these species[4].

The blood trauma in the present experiments was of the same general degree as that in the current heart–lung machines. On the other hand, exogenous adenosine triphosphate and 5-hydroxytryptamine at minute dose-levels have been reported to elicit vasodilatation and systemic hypotension[3,5,12]. Intense bronchoconstriction[5], pulmonary vasoconstriction[1] and potentiation of the action of hypnotics (barbiturates)[13] are further reactions to exogenous 5-hydroxytryptamine. With these facts in mind it seems possible that the complications associated with the use of heart–lung machines for open cardiac surgery, such as hypotension, cyanosis and a delay in the recovery from anæsthesia with eventual death[1], might be largely effected by such physiologically highly active agents as adenosine triphosphate and 5-hydroxytryptamine liberated into plasma from injured cellular blood constituents. Significantly enough, even in the present experiments deepening of the anæsthetic-level during extracorporeal circulation, as well as a delay in the recovery from anæsthesia, were repeatedly observed. In addition, 5-hydroxytryptamine has been found to be about one hundred times as effective as histamine in raising capillary permeability and in producing œdema[14]. Taken together with the above results, it also seems possible that such unexplained features as the œdematous changes in perfusion preparations of different types and more particularly the myocardial œdema, continuously increasing coronary flow and "Spontaninsuffizienz" known to occur in the heart-lung preparations[15] would be causally related to the humoral pathological blood changes under consideration. The present results are being described and discussed in detail elsewhere[16].

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AMPLITUDE-MODULATION RADIO-TELEMETRY OF NERVE ACTION POTENTIALS

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INFORMATION concerning the functioning of intact animals has been successfully telemetred to remote points from satellites, missiles, large centrifuges and other situations[1]. The present report describes experiments in which the response of a single type of excitable tissue (nerve trunk or fibre) was relayed to and recorded at a distant point by telemetry. The basic problem is one of transmitting a pulse to the preparation at a distant point, and receiving the response to this stimulus at the point of transmission.

This series of experiments passed through several phases which will be described in another communication[2]. The system made use of two radio links, one for each direction in which information was to flow, and was set up in one building. The required stimulating pulse was produced by a Grass *S4-C* stimulator and used to amplitude-modulate a Hallicrafters *S-27RS* radio transmitter by means of the Model 115 amplitude-modulator of Measurements Laboratory (Boonton, New Jersey). The modulator operated at a minimum external modulating frequency of 30 cycles, provided up to 100 per cent modulation with low envelope distortion, allowed accurate metered per cent modulation calibration, and produced amplitude modulation of the stimulus intelligence with negligible accompanying incidental frequency modulation, thus allowing narrow-band receiver operation. In accordance with amplitude modulation theory, the stimulus, or modulating voltage, was introduced in the plate voltage supply line and added to the plate supply voltage at a rate and magnitude determined by the modulating signal and the modulator output. In this type of system, developed by Hartley, the carrier signal originates in a crystal-controlled oscillator, is raised to full power by amplifiers, and is modulated in the final stage of power amplification which operates Class *C*. Since the load is fixed, as the voltage level changes because of the modulation, the tank voltage swing, the plate current operating angle, and the current-pulse form and amplitude change so that the d.c. plate voltage varies linearly with respect to the square root of the power output. This permits distortionless amplitude modulation, but the modulator must supply power equal to one-half of the unmodulated carrier power at 100 per cent modulation.

The radio-frequency carrier can be expressed as $y = A\,(t) \cos \gamma\,(t)$ and in amplitude modulation the signal intelligence (nerve stimulus and response) is made to control the amplitude parameter of the carrier by the relation:

$$A\,(t) = [A0 + af(t)] = [A0\{1 + maf\,(t)\}]$$

The scheme for the plate-operated output stage and a block diagram of the entire system will be found in Fig. 1. A complete mathematical analysis of the carrier and amplitude spectra may be found elsewhere[3].

The antenna used to recover the signal at a distant point was a vertically mounted dipole designed for optimum reception of the tuned frequency (72·25 Mc./s.), fed into a coaxial transmission cable. The intelligence present in the amplitude-modulated wave was recovered by impressing the modulated

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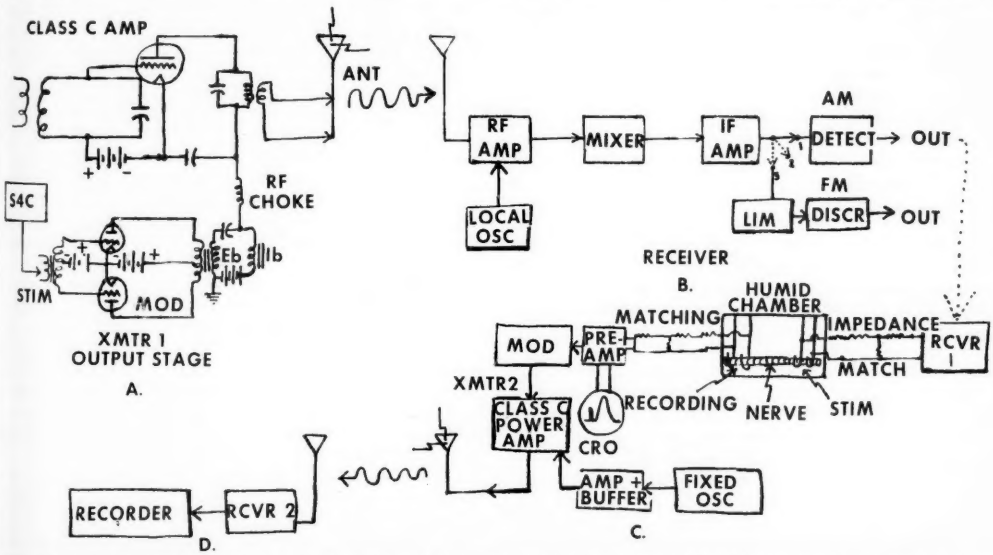

Fig. 1 (*A*). Plate-modulated output stage. Explanation in text. Transmitter I relays stimulus signal to receiver I. (*B*) Receiver I demodulates signal intelligence and (*C*) impresses stimulus on to stimulating electrodes via impedance network. Pick-up electrodes feed response through matching network to transmitter II, then relay response (also monitored on CRO) back to (*D*) receiver II, where it is demodulated, amplified and drives pen-recorder

wave on a non-linear network which, for low-strength signals, employed a voltage-current characteristic represented by the following terms of a Taylor series :

$$i = I_b + G_1 e + G_2 e^2 \qquad (1)$$

where the predominant term is $G_2 e^2$. The carrier and first side-frequency pair which result from the amplitude-modulation of the carrier $E_0 \sin\omega_0 t$ by the modulating wave $ME_0 \cos\omega_1 t$ were impressed at the input of this network. The impressed voltage, containing the stimulus intelligence, can then be written :

$$e = E_0 \sin\omega_0 t + \frac{ME}{2^0} \{\sin(\omega_0 + \omega_1) t + \sin(\omega_0 - \omega_1) t\} \qquad (2)$$

It is found by combination and substitution that the square-law term yields a series of waves. The wave corresponding to the original intelligence is $G_2 ME^{2\cos\omega_1 t}$. Its amplitude is proportional to the square of the voltage. This wave was then amplified and fed through a network which matched the output impedance of the receiver to the bipolar stimulating electrodes. In operation, the receiver's *S*-meter was used as a carrier-level indicator for amplitude modulation, and the best records were obtained with the receiver tuned slightly to one side of the carrier frequency. A Ferris model 18-*B* signal generator was used to align the receiver, which was also a Hallicrafters model *S*-27*RS*. In later experiments employing frequency modulation a separate stage of the receiver assembly, known as the 'frequency unit', rectified the alternating current output of the receiver, and the d.c. output of the frequency unit was fed to a visual meter and recorder.

The response of the preparation was picked up by silver–silver chloride electrodes, and after source-impedance matching and amplification, modulated another radio transmitter which transmitted the information back to the originating point. Here, after demodulation and amplification, the pulses were used to activate a strip-chart recorder (Leeds and Northrup Speedomax Type *G* Model *S* 60000 series). Sciatic nerves of bullfrogs (*Rana catesbiana*) and radial or ulnar nerves of dogs (*Canis canis*) were used. A total of 11 nerves was tested. Single motor fibres were used in some experiments, which closely followed the bridge-insulator technique of Tasaki[4]. Details of those studies will be included in ref. 2. With the distal end crushed, whole nerves were placed on two pairs of electrodes in a humid chamber at 20° C. The location of the active pick-up electrode was 7·5 cm. distal to the stimulating cathode and 1·2 cm. proximal to the inactive pick-up electrode. The distal electrode was connected to earth and the proximal one was anode during the pulse. The monophasic action potential was monitored at the site of the preparation by d.c. amplification and display on an oscilloscope. The stimulating pulse, measured at the output of the distant receiver, was 0·1–0·5 msec. in duration, and its amplitude was adjusted to be supramaximal for beta fibres.

The duration of the responses was 1–3 msec. and the maximum amplitude about 30 mV. The wave form of the action-potential was not recorded, but simply the fact of its having occurred. The portion of the record in Fig. 2 shows the responses of the inkwriter to slow stimulation rates, and shows also that the write-out is proportional to amplitude. Thresholds as determined by the onset of activity of the inkwriter varied from 14 to 15 mV., and did not

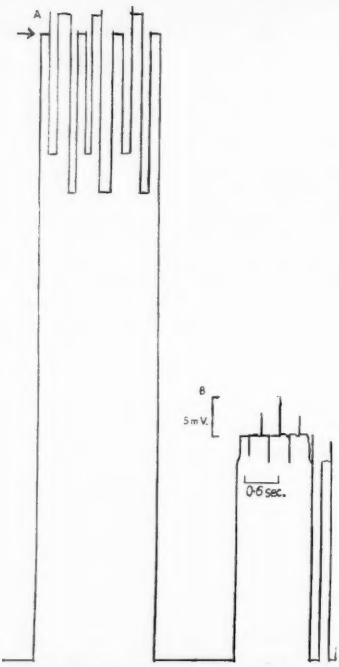

Fig. 2. Photograph of segment of ink write-out showing (*A*) threshold of 15 mV. (at arrow) for a single nerve

differ significantly for amphibian as compared with mammalian nerve.

Conduction velocity was determined by the spacing between the rectangular pulse outlines on the record and ranged in all nerves from 23·5 to 36·8 m./sec. In some experiments reproducible records were easily obtained for 15–20 hr., during part of which the whole system could be left unattended except for changing the paper or filling the ink-reservoir of the recorder. For auditory monitoring during such periods a loudspeaker was connected to the 5,000-ohm terminals of receiver II.

The special problem encountered in this application of telemetry is the matching of receiver output and input impedance-levels to bipolar stimulating and recording electrodes and the matching of the transmitter modulator inputs to the output of the stimulated nerve, with the assumption that the resting resistance is about 20 k.-ohms max. and that the resistance during activity is no more than 10 per cent of that value.

Theoretically it is possible for the nerve to be stimulated by the carrier wave itself. In general, for carrier frequencies at which losses in the preparation are not too great, the shape of the carrier envelope for the directly applied carrier would be expected to have the same shape as that obtained with a d.c. pulse. Since the response is transmitted over a radio link it is more convenient to use the d.c. pulse for stimulation.

The electrical process of the nerve impulse is a signal similar to those encountered in data-handling telemetry systems used for aircraft and missile testing and for satellite experiments. It is now possible to determine the effect on the whole nerve or single fibre (if properly packaged) of magnetic, gravitational or radiation fields at very high altitudes.

in vehicles undergoing changes in acceleration. The long periods of time during which the output of the nerve is relatively constant when stimulated remotely by a constant stimulus assure adequate data for statistical analysis. The method therefore allows measurement of changes in angular acceleration, both positive and negative. Basic physiological data which can be collected in such circumstances include threshold, rheobase, chronaxie, strength-duration and strength-latency curves, refractory periods and critical stimulus interval for 2 stimuli. Controlled variation in potentials led from electrodes implanted in animal brains can also be studied by this means, either on the ground or in guided or orbital flight. By using a frequency modulated/frequency modulated multichannel system of the type commonly employed in satellite research, the wave-form of the action potentials can be recovered with fidelity through high-frequency interrogation during the passage of impulses. Its relationship to environmental variables can then be determined. With interval-measuring equipment at present available, nerves might be used in orbital vehicles as biological clocks to determine directly whether or not there is a relativistic shift for excitable tissue[5]. This cannot be done at present with intact animals or astronauts.

I wish to thank Messrs. W. Boynton, R. Bottom, and A. Fisher of the United States Weather Bureau for valuable advice concerning the operation of the transceiver units. Mr. P. Baby of Electromechanical Research, Inc., furnished helpful references.

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COMPOSITION OF A PARAFFIN WAX FRACTION FROM TOBACCO LEAF AND TOBACCO SMOKE

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THE paraffin wax of tobacco leaf and smoke is generally regarded as a mixture of *n*-paraffinic hydrocarbons, with *n*-hentriacontane as the major component[1–3]. The isolation of pure paraffinic hydrocarbons from both leaf and smoke has been claimed in a number of instances[4,5], but it is open to question whether the specimens were, in fact, homogeneous, for in every case the melting point was the only criterion of purity employed and it has been shown that melting points alone do not afford a reliable guide to the purity of paraffinic hydrocarbons[6].

We have obtained additional evidence of the complex nature of the wax through mass spectroscopic and gas-liquid chromatographic analyses of fractions obtained from green tobacco leaf (*Nicotiana tabacum*, Delcrest variety), from the 'black' fermented tobacco of a variety of Argentinian cigarettes and from the smoke of these cigarettes. The analyses were very kindly carried out for us at Thornton Research Centre, 'Shell' Research, Ltd., through the generosity of Dr. R. Graham, and the results, shown in Tables 1 and 2, indicate clearly that the wax from each of the three sources is a mixture of broadly similar composition. *n*-Hentriacontane is the main individual component, but appreciable quantities of the neighbouring odd-numbered homologues and small amounts of the even-numbered homologues are present as well. Dr. Graham has informed us that the precision of the mass-spectroscopic analysis is not high, and no significance should thus be attached to the apparent small differences in composition of the three waxes. An interesting and novel feature of the results is the high proportion of *iso*-alkanes disclosed by mass spectroscopy. So far as we are aware, *iso*-alkanes have not previously been detected in the paraffin wax of tobacco or indeed of other plants, although their presence in cigarette smoke has been noted[3]. (Since writing this article, we have seen a publication by Mme. Suzanne Barbezat (*J. Recherches du Centre National de la Recherche Scientifique*, **45**, 273; 1958) in which it is reported that the paraffins of tobacco and tobacco smoke, though predominantly normal, may contain branched chain isomers. Dr. A. I. Kosak has also informed us that he and Dr. J. S. Swinehart have detected branched chain isomers in the paraffin fraction of cigarette smoke. We are

Table 1. Mass Spectroscopic Analysis of Paraffin Waxes

Carbon No.	Source of wax: Green leaf			Fermented tobacco			Cigarette smoke		
	n-Alkanes	*i*-Alkanes	Total	*n*-Alkanes	*i*-Alkanes	Total	*n*-Alkanes	*i*-Alkanes	Total
25	0·9	0	0·9	0·7	0	0·7	0	0	0
26	0·6	0	0·6	1·2	0	1·2	0·5	0	0·5
27	3·0	0·9	3·9	5·9	0·8	6·7	5·2	0·8	6·0
28	0·1	0	0·1	0·9	0	0·9	0·5	0	0·5
29	6·6	15·9	22·5	6·3	11·0	17·3	5·2	15·3	20·5
30	0·9	2·5	3·4	0·6	1·6	2·2	1·0	1·5	2·5
31	24·1	24·4	48·5	26·6	20·4	47·0	25·7	20·2	45·9
32	3·9	2·4	6·3	5·1	2·0	7·1	4·3	1·9	6·2
33	10·8	3·3	14·1	13·1	3·9	17·0	14·3	3·5	17·8
Total	50·9	49·4	100·3	60·4	39·7	100·1	56·7	43·2	99·9

The *n*-alkane/*i*-alkane ratio is based on an accepted sensitivity ratio of 1/10.

Table 2. Gas-liquid Chromatographic Analysis of Paraffin Waxes

	Green leaf wax	Fermented tobacco wax	Cigarette smoke wax
Percentage area $n-C_{24}$	—	—	0·1
" " $n-C_{25}$	0·5	—	0·6
" " $n-C_{26}$	0·3	0·3	0·4
" " $n-C_{27}$	7·5	4·4	6·3
" " $n-C_{28}$	0·6	1·0	1·1
" " $n-C_{29}$	8·8*	9·2*	7·4
" " $n-C_{30}$	3·9†	7·1	3·8†
" " $n-C_{31}$	47·0*	46·5*	43·4*
" " $n-C_{32}$	12·5	16·0	13·0
" " $n-C_{33}$	18·9*	15·5*	22·8*
" " $n-C_{34}$	—	—	1·1

Column 3 ft., silicone grease *E* 301 on 52–85 mesh 'Silocel' at 288° C.; nitrogen flow-rate, 1·6 l./hr.

* These peaks were composed of two unresolved peaks. The results given include both peaks. The impurity is probably a very slightly branched paraffin.

† These peaks were probably due to $n-C_{30}$ paraffins but this was not fully confirmed.

indebted to these authors for telling us of this result before publication.) The Thornton workers have interpreted the present results as due to the presence of 2-methylalkanes.

For the preparation of the materials for analysis, neutral extracts of the tobacco and a neutral fraction of the cigarette smoke condensate were chromatographed on alumina and the initial waxy fractions eluted with light petroleum (b.p. 40–60° C.) were treated with urea in warm methanol[7]. The resulting adducts were washed with light petroleum, decomposed with water, and the recovered paraffins crystallized once from benzene-ethanol. The melting points and elementary analyses are shown in Table 3. The waxes showed no light absorption in the ultraviolet, indicating the absence of unsaturated compounds, and their infra-red spectra determined on a Perkin–Elmer 'Infracord' spectrometer were very similar to that recorded for *n*-triacontane[9]. The method of isolation does not rule out the presence of *iso*-paraffins, for it is known that slightly branched paraffins will form urea adducts if the main chain is long enough[8]. Attempts to obtain additional evidence for the presence of *iso*-alkanes by high resolution infra-red spectroscopy in the 1,500–1,300 cm.$^{-1}$ region were inconclusive in the absence of suitable reference compounds.

Table 3

Source of wax	Green leaf	Fermented tobacco	Cigarette smoke
Melting point	60–63° C.	60–63° C.	61–64° C.
Elementary analyses	C, 85·4 H, 14·5	C, 85·4 H, 14·3	C, 85·4 H, 14·5

Little consideration appears to have been given to the possibility that the considerable amounts of paraffin wax in cigarette smoke may play some part in its carcinogenic activity[10]. In this connexion, attention might be directed to the report by Horton, Denman and Trosset[11] that the production of tumours on mouse skin by 3 : 4-benzpyrene and by 20-methylcholanthrene was considerably accelerated and the tumour incidence increased when the carcinogens were applied in conjunction with a large excess of certain high molecular weight hydrocarbons, including some *n*-paraffinic hydrocarbons. It is not inconceivable that a similar combined action of the paraffins and the carcinogenic aromatic hydrocarbons[12] in cigarette smoke may contribute to the carcinogenic activity towards mouse skin of the smoke, and may account, in some measure, for the fact that the smoke is more potent than might be expected from its very small content of aromatic hydrocarbon carcinogens[13].

In other experiments we have prepared the methyl esters of acids obtained from the flue-cured tobacco of a variety of British cigarettes, and a fraction of the esters b.p. 190–210°/0·5 mm. has also been analysed by mass spectroscopy and gas-liquid chromatography at the Thornton Research Centre. To obtain the esters the tobacco was extracted with chloroform, and the alkali-soluble fraction treated briefly with ethereal diazomethane. The mass spectroscopic results (Table 4) show that methyl palmitate is the major component of the mixture, accompanied by some stearate and smaller amounts of a number of other higher and lower homologues. A considerable amount of C_{18} unsaturated esters is also present, with methyl linolenate predominating. An essentially similar result was obtained in the gas-liquid chromatographic analysis. Most of the acids corresponding to these esters have already been found in cigarette smoke, in which palmitic acid and C_{18} unsaturated acids appear to be particularly abundant[2,5]. Palmitic acid was also found to be the principal fatty acid of an American bright green leaf by Hellier[14], and it is of interest that the palmitate and linolenate were the main components of a mixture of solanesyl esters recently isolated from an American flue-cured leaf[15]. A mixture said to contain methyl laurate, myristate and palmitate has also been obtained from a Japanese flue-cured tobacco[16].

Table 4. Mass Spectroscopic Analysis of Tobacco Methyl Esters*

Ester	Acid carbon No.	Ester molecular weight	Peak height	Relative sensitivity	Relative quantity
Caprate	10	186	6	0·20	30
	11	200	4		
Laurate	12	214	3	0·42	7
	13	228	0		
Myristate	14	242	7	0·63	11
	15	256	6		
Palmitate	16	270	297	0·80	352
Margarate	17	284	25		
	18†	288	12		
Arachidonate	18†	290	31		
Linolenate	18†	292	115		
Linoleate	18†	294	73		
Oleate	18†	296	13		
Stearate	18	298	70	1·00	70
Nonadecylate	19	312	7		
Arachidate	20	326	19		
	21	340	4		
Behenate	22	354	11		
	23	368	4		
	24	382	4?		
	26	410	3?		

* Because of lack of knowledge of the relative sensitivities of many of the compounds the results can only be reported incompletely.
† Unsaturated.

We are very greatly indebted to Dr. Robert Graham and the mass-spectroscopic and gas-liquid chromatographic research groups of Thornton Research Centre, 'Shell' Research, Ltd., for the mass spectroscopic and gas-liquid chromatographic analyses. We thank, also, Mr. Ivan Neas, director of the Tobacco Research Board of Rhodesia and Nyasaland, for supplying the green tobacco leaf, Dr. J. R. Plimmer for the crude wax fraction of the green leaf, and Dr. J. W. Cook for his interest in the investigation.

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HÆMOGLOBIN ^{D} IN A FAMILY IN THE BELGIAN CONGO

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A SURVEY of abnormal hæmoglobins has been carried out on 1,000 African pregnant women visiting the Outpatients Department of the Government Hospital at Stanleyville. The results will be published in detail elsewhere, but it is of interest here that on two occasions hæmoglobin *P* was discovered. Hæmoglobin *P* was first described by Schneider and Haggard[1]. On paper and open boundary electrophoresis at alkaline *p*H, hæmoglobin *P* moves more slowly to the positive pole than hæmoglobin *A* and separates from that pigment. It moves faster than hæmoglobin *S* but does not separate from a mixture of *S* and *P*. Under these conditions it cannot be distinguished from hæmoglobin *L*. On electrophoresis in acid *p*H, either in citrate agar or by the open boundary technique, and in resin chromatography, hæmoglobin *L* separates widely from hæmoglobin *A*, whereas hæmoglobin *P* does not separate. Thus hæmoglobins *L* and *P* can be differentiated by these procedures.

In one of the findings of hæmoglobin *P* an extensive family study was made (Fig. 1). The propositus was a 24-year old Bantu female of pure Lokele descent. Originally the Lokele lived on the River Congo, but the propositus and her family had settled in Stanleyville. She was eight months pregnant when first seen and seemed perfectly well. She had three children who were alive and healthy. Laboratory examinations revealed the presence of *Pl. falciparum* in her blood and ankylostoma ova in her stools. She suffered from a moderate hypochromic anæmia, which was corrected by treatment with antimalarials and iron, and the mean corpuscular hæmoglobin concentration rose from 26 to 31·8 per cent, and the mean corpuscular hæmoglobin from 24·3γγ to 31γγ. Her serum iron-level at the end of the treatment was 117γ per 100 ml.

On paper electrophoresis at alkaline *p*H her hæmoglobin separated into two fractions, one hæmoglobin *A* and another moving more slowly in

Table 1. Findings in a Family in which Hæmoglobins *A*, *S* and *P* are found as Adult Variants, and in which a Proportion of the Members of the Family show Significant Traces of Hæmoglobin *F* without Microcythæmia

Pedigree designation	Name	Sex	Age	Sickle-cell trait	Adult hæmoglobins	Alkali resistant hæmoglobin (per cent)	Red cells (per cu.mm.)	Cell volume (per cent)	Hæmoglobin gm./100 ml.	M.C.H.C.* (per cent)	M.C.V.* (cu. μ)	M.C.H.* (γγ)	Reticulocytes (per cent)	Blood group
I 1	Kamanga	*M*	65	0	*AP*	1·8	4,450,000	41·8	13·8	33	93·8	31	0·6	A_2 N ccDE
I 2	Malasi	*F*	65	+	*AS*	1·6	4,385,000	40	13·5	33·7	91·2	30·8	0·3	A_1 M CcDee
II 1	Salumu Boniface	*M*	31	+	*APS*	3·9	5,080,000	47	15·1	32·1	92·5	29·7	1	A_1 MN CcDee
II 2	Fatuma Justine	*F*	28	0	*A*	<1·5	3,780,000	38	11	28·9	100·5	29·1	0·7	0 MN ccDee
II 3	Yawenda Hiéronyme	*F*	27	0	*A*	<1·5	4,570,000	42	14·3	34	91·9	31·3	0·7	A_1 MN ccDE
II 4	Safi† Yalufi	*F*	25	0	*AP*	6	3,880,000 (3,660,000)	36·2 (11·4)	9·4 (11·4)	26 (31·8)	93·4 (97·5)	24·3 (31)	0·5	A_1 MN CcDE
II 5	Ngulaia Bernard	*M*	26	0	*A*	<1·5	4,480,000	43	13·1	30·5	95	29·3	0·9	0 MN ccDee
II 6	Kilicho Alphonse	*M*	22	+	*AS*	<1·5	5,600,000	46	14	30·4	82·1	26·7	0·2	A_1 MN ccDE
II 7	Aziza Marie-Louise	*F*	19	0	*A*	<1·5	4,025,000	39	12·7	32·5	96·8	33·1	1	0 MN ccDee
III 1	Salumu Albert	*M*	12	0	*AP*	3·1	4,600,000	40	12·7	31·7	86·9	27·6	0·3	A_2 MN CcDee
III 2	Salumu Mélanie	*F*	9	0	*AP*	7·3	4,370,000	38	13·1	34·5	86·9	30	0·6	A_1 MN CcDee
III 3	Salumu Excell	*M*	7	+	*AS*	<1·5	4,390,000	37	13·1	35·5	84·2	29·9	0·7	A_1 MN CcDee
III 4	Salumu Tabu	*F*	6	+	*AS*	1·6	3,365,000	30	8·7	29	89·3	25·9	2	A_2 MN CcDee
III 5	Salumu Félicité	*F*	5	0	*AP*	1·7	4,085,000	37	11·3	30·5	90·5	27·6	2	A_1 MN ccDee
III 6	Salumu Côme	*M*	2	+	*AS*	<1·5	3,600,000	32·5	10·7	32·9	90·2	29·7	0·7	A_1 MN ccDee
III 7	Ngulaia† Boniface	*M*	7	0	*AP*	5·2	3,840,000 (3,500,000)	30 (32)	9·4 (10·4)	31·4 (32·4)	78·1 (91·1)	24·5 (29·6)	1·1	A_1 MN ccDE
III 8	Ngulaia† Christine	*F*	5	0	*AP*	3·9	4,500,000 (4,520,000)	37 (39)	11·5 (12·4)	31·1 (31·8)	82·2 (86·2)	25·5 (27·4)	0·3	A_1 MN ccDE
III 9	Ngulaia† Marie-Colette	*F*	2	0	*A*	19·8	4,520,000 (4,260,000)	37 (37·5)	11·7 (12·2)	31·6 (32·5)	81·8 (88)	25·8 (28·6)	0·4	0 MN ccDE
III 10	Kiditio Marguerite	*F*	2	0	*A*	2·5	4,225,000	39·5	12	30·4	93·4	28·4	0·3	0 MN ccDE
III 11	Kiditio Valerine	*F*	9 12	+	*AS*	3·1	4,400,000	36	11·1	30·8	81·8	25·2	0·2	0 N ccDE

*Key: M.C.H.C., mean corpuscular hæmoglobin concentration; M.C.V., mean corpuscular volume; M.C.H., mean corpuscular hæmoglobin.

† The figures in brackets show the results after the removal of hookworms and treatment with antimalarials and iron. In all subjects nothing abnormal was seen in the white cell count, and the serum bilirubin-level was raised.

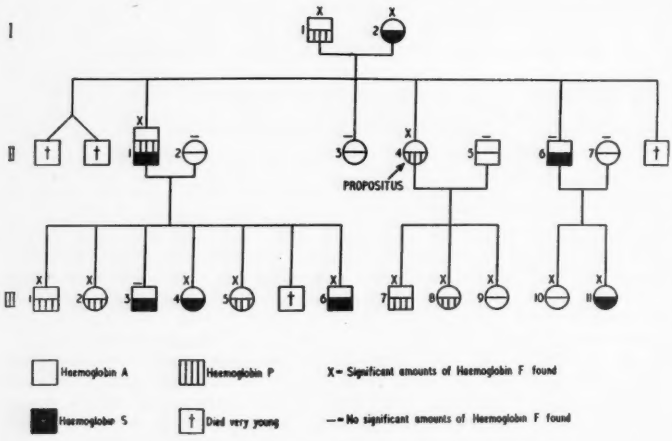

Fig. 1

the positions of hæmoglobins *L* or *P*. On resin chromatography at *p*H 6 the hæmoglobin mixture did not separate, although a tail appeared at the rear of the hæmoglobin *A* band, which is the typical appearance of a hæmoglobin *A* + *P* mixture. We sent two samples of the patient's hæmoglobin to Dr. R. Schneider, who confirmed by paper electrophoresis at *p*H 8·6 and by open boundary electrophoresis at *p*H 6·4, and by electrophoresis in citrate agar at *p*H 6·0, that the abnormal hæmoglobin had the properties of hæmoglobin *P*.

When the family was examined it became apparent that a number of them showed traces of hæmoglobin *F*, but the hæmoglobin fraction A_2 was always below 3 per cent (Table 1). This applied to the parents of the propositus, to all her children, to one of her siblings, and seven of eight nephews and nieces examined. Two of her siblings showed no hæmoglobin *F*, but two nieces with hæmoglobin *F* were the daughters of one of these siblings. The family tree did not show an association of hæmoglobin *F* with either hæmoglobins *A* or *P*, or with a third hæmoglobin occurring in the family—hæmoglobin *S*. The only case where the amount of hæmoglobin *F* was considerable was that of a niece (III 9)—a two-year old child with 19 per cent fœtal hæmoglobin. There was a slight hypochromia but no serious anæmia, and there was no increase in hæmoglobin A_2 as might be expected in typical thalassæmia.

In one of the propositus' brothers (II 1) four hæmoglobins were found. Alkaline denaturation and resin chromatography at *p*H 6 demonstrated 4 per cent hæmoglobin *F*. On paper electrophoresis at *p*H 8·6 two fractions were seen: hæmoglobin *A*, and another larger, slow-moving component in the position of hæmoglobin *S*. On chromatography at *p*H 6 three fractions were seen, one corresponding to hæmoglobin *F*, and two others: one in the position of hæmoglobin *A* with tailing resembling the appearance of an *A* + *P* mixture; and another in the position of hæmoglobin *S*. Whereas the fraction in the position of hæmoglobin *S* had been the largest on paper electrophoresis at alkaline *p*H, it was now smaller than the component moving in the position of hæmoglobin *A*. These findings could be interpreted as indicating the presence of hæmoglobins *A*, *P* and *S*, the *P* moving with *S* on alkaline paper electrophoresis, and with *A* on chromatography *p*H 6. The family study supported this interpretation. This man had married a woman with normal hæmoglobin, and three of his offspring showed hæmoglobins *A* + *P*, and three others hæmoglobins *A* + *S*. The genotype *A* + *S* + *P* was therefore borne out by the family study.

Hæmoglobins *S* and *C* have been shown to be determined by allelic genes[2]. Ingram[3], and Hunt and Ingram[4] have demonstrated that the difference between hæmoglobins *A*, *S* and *C* consists in a substitution of different amino-acids in one position of the hæmoglobin half-molecule. The possibility that there might be more than one locus determining specific features of adult hæmoglobin was first suggested by Schwartz and his colleagues[5] to explain the mode of inheritance of hæmoglobins *A*, *S* and what they considered to be hæmoglobin *G*, in a family they had studied. This interpretation has also been proposed by Smith and Torbert[6] to explain their

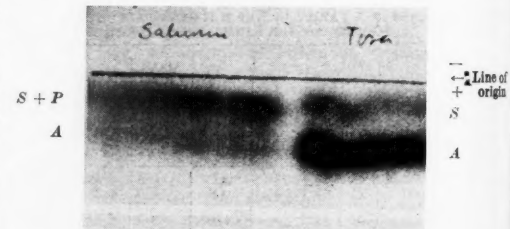

Fig. 2. Paper electrophoresis at *p*H 8·9 (*tris* buffer) showing above II 1 (*A* + *P* + *S*) in comparison with his son III 4 (showing *A* + *S*) and below with his daughter III 5 showing *A* + *P*. The bands are unstained

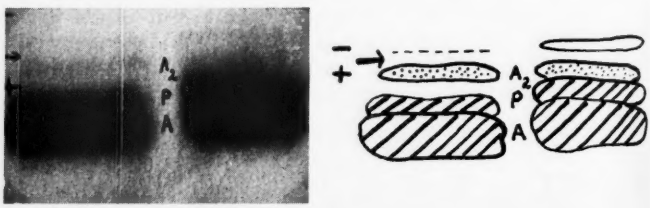

Fig. 3. Hæmoglobin from the propositus (*A* + *P* + *F*) before and after dissociation and re-combination. Paper electrophoresis at *p*H 8·9 (*tris* buffer). The bands are stained with 'light green'. In the re-combined specimen a small component is seen moving towards the anode

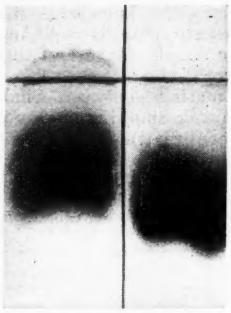

Fig. 4. Paper electrophoresis at *p*H 8·6 (barbiturate buffer) showing a comparison between the hæmoglobin of the propositus ($A + P + F$) and a hæmoglobin $A + S$ mixture after dissociation and re-combination. The bands have been stained with 'light green'. Note that in the specimen from the propositus a fraction is present which moves towards the anode. This fraction is not present in the $A + S$ mixture

findings in a family with hæmoglobins *A*, *S* and a 'fast' moving hæmoglobin. Lastly, Cabannes and Portier[7] have described a family where the mother possessed hæmoglobins *A*, *D* and *K*. One of her children was a hæmoglobin *D* trait carrier, and the other two were hæmoglobin *K* trait carriers. It seems that hæmoglobin *P* joins the group of adult variants whose inheritance could be interpreted as being under different control from that responsible for hæmoglobins *S* and *C*. Rhinesmith, Schroeder and Pauling[8] demonstrated that the hæmoglobin *A* molecule contains only two types of polypeptide chains, and Schroeder and Matsuda[9] have shown that hæmoglobin *F* also consists of an equal number of two polypeptide chains, one of which has been found by Hunt[10] to be identical with that common to hæmoglobins *A*, *S* and *C*. Ingram[11] has pointed out how two non-allelic genes could find expression by one affecting the first, and the other the second, chain. Singer and Itano[12] were able to show that exchange of chains between hæmoglobins *A*, *S* and *C* did not result in any 'hybrid' hæmoglobin. This one would expect if in all three hæmoglobins one of the two chains was identical. On the other hand, if in hæmoglobin *P* the alteration was not in the same chain which is different in hæmoglobins *S*, *C* and *F*, then a dissociation and re-combination of a hæmoglobin mixture containing hæmoglobins *A*, *P* and *F* should result in at least one 'hybrid' hæmoglobin.

Following Singer and Itano[12] a purified solution of hæmoglobin from the propositus ($A + P + F$) was incubated with acetate buffer *p*H 4·6. It was then dialysed against barbiturate buffer *p*H 8·6, and a small amount of precipitate formed during dialysis was removed by centrifugation. On paper electrophoresis of the supernatant at *p*H 8·6 a new hæmoglobin fraction was seen moving towards the cathode (Fig. 3). This fraction could be eluted and was shown spectroscopically to be a hæmoglobin. No such fraction was found when specimens of hæmoglobins $A + S$, $A + C$, and $S + C$ were similarly examined. However, when untreated specimens of hæmoglobin from the propositus were submitted to starch electrophoresis where a larger amount of pigment could be investigated, a minute fraction corresponding to the 'hybrid' hæmoglobin was detected (Fig. 3). It is not possible to state with assurance that this fraction was not formed on storage of the hæmoglobin solution. However, if the 'hybrid' hæmoglobin was an *in vivo* phenomenon, the situation would resemble that known to occur in plants where anthocyanin formation is determined by independent genes, and 'hybrid' pigments can be formed. In II 1 ($A + S + P + F$) only the 'hybrid' seen in the propositus was found on dissociation and re-combination of the hæmoglobin mixture. Similarly, mixtures of hæmoglobins $A + S$, or $S + C$ with that of the propositus did not result in additional 'hybrids'. However, here a large amount of precipitate was formed during dialysis and the soluble fraction had lost most of the non-*A* hæmoglobins.

From the position of these hæmoglobins on electrophoresis at alkaline *p*H, and from the work of Hunt and Ingram[3,4], it is clear that the substituted chains of *S* and *C* carry a much stronger positive charge than the characteristic chain of hæmoglobin *F*, and one might expect their combination with the characteristic *P* chain to be unstable.

We wish to thank Dr. A. E. Mourant and Dr. V. M. Ingram for helpful discussion.

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β-GLOBULIN ALLELES IN SOME ZEBU CATTLE

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National Cattle Breeding Station, Commonwealth Scientific and Industrial Research Organization Laboratory, Rockhampton, Queensland

THREE β-globulin alleles (β^A, β^D and β^E) have been described so far in British breeds of cattle[1]. Two further alleles have now been recognized in zebu (*Bos indicus*) breeds. It is proposed to call these alleles β^B and β^F.

In most mammals the β-globulin alleles give rise to more than one zone by starch-gel electrophoresis[2]. Each of the cattle β-globulin alleles β^A, β^D and β^E gives four detectable zones, the most rapidly migrating zone staining faintly with nigrosine, the next staining moderately and the slowest two zones staining intensely. The two further alleles which have been detected also give rise to four similarly staining zones. The relative mobilities of the groups of four

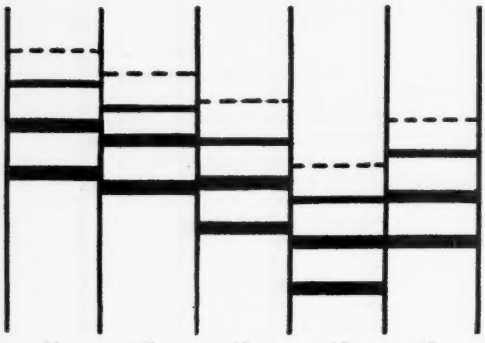

Fig. 1. Relative mobility in starch-gel of the four zones produced by each β-globulin allele in cattle. The anodic side of the gel is at the top of the diagram, only the β-globulin zones being shown

zones controlled by the five alleles are shown in Fig. 1. It will be seen that the zones controlled by β^B are intermediate in mobility to those produced by β^A and β^D, while β^F gives rise to zones intermediate in mobility between those produced by β^D and β^E.

Previous experience has shown that each β-globulin genotype formed from the alleles β^A, β^D and β^E gives only one phenotype[1]. Fifteen phenotypes would therefore be expected from five alleles; fourteen have been found so far. The homozygote of the infrequent allele β^B has not yet been seen. The appearance of the phenotypes (Fig. 2) was anticipated

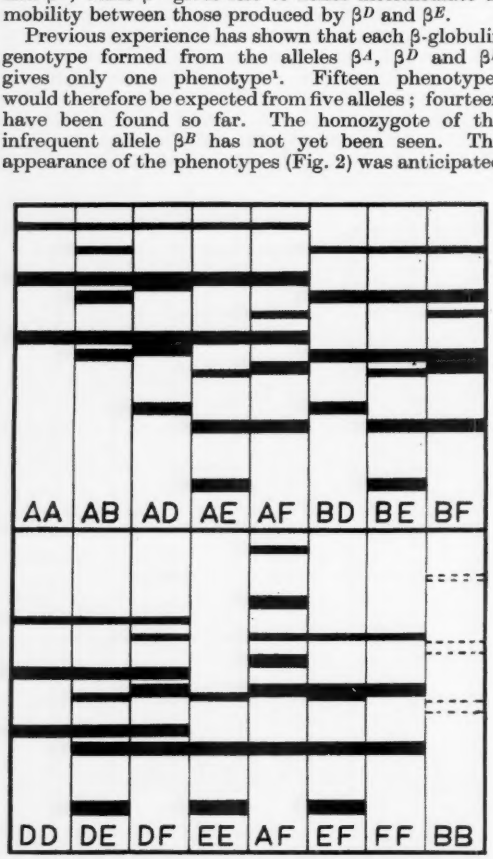

Fig. 2. The fourteen cattle β-globulin phenotypes. The anodic side of the gel is at the top of each portion of the diagram, only the β-globulin zones being shown. The fast-moving faint band produced by each allele (cf. Fig. 1) is not shown. For *AA*, *AB*, etc., read β^{AA}, β^{AB}, etc. The dotted zones for β^{BB} (bottom right) show the expected appearance of this phenotype, which has not yet been found

in the main from the knowledge that the pattern given by a heterozygote is indistinguishable from that given by a simple mixture of the corresponding homozygous sera[1,2].

Data from matings between Sindhi × Sindhi, Sahiwal × Sahiwal, Sindhi × Jersey and Sahiwal × Jersey cattle confirm that the previously unrecognized phenotypes represent individual genotypes formed from five alleles (Table 1).

Table 1. Distribution of Phenotypes from Matings involving the Cattle β-Globulin Alleles β^B and β^F

Parents		Offspring		
Dam	Sire	Like dam	Like sire	Recombinants
*AA**	*AF*	3	3	—
AA	*BF*	—	—	1 *AB*
AD	*AF*	1	9	3 *AA*, 5 *DF*
AD	*BF*	—	—	1 *AB*, 1 *BF*
AD	*FF*	—	—	1 *DF*
AE	*AF*	5	0	0
BF	*AF*	1	0	0
DD	*AF*	—	—	1 *AD*, 4 *DF*
DD	*DF*	—	—	1 *DF*
EF	*AF*	0	1	1 *FF*
EF	*DF*	1	1	0

* For *AA*, *AF*, etc., read β^{AA}, β^{AF}, etc.

The frequency of each allele for several breeds and crossbreeds of cattle from two herds is shown in Table 2.

Table 2. Showing β-Globulin Gene Frequencies for some Breeds and Cross-breeds of Cattle at F. D. McMaster Field Station (top) and National Cattle Breeding Station (bottom)

Breed	No. of animals	Gene frequency				
		β^A	β^B	β^D	β^E	β^F
Sindhi	14	0·57	0·04	Nil	0·28	0·11
Sindhi × Jersey	29	0·52	Nil	0·24	0·12	0·12
Sahiwal	10	0·10	0·20	Nil	0·15	0·55
Sahiwal × Jersey	31	0·33	0·05	0·28	0·03	0·31
Jersey	51	0·51	Nil	0·49	Nil	Nil
Hereford	27	0·39	Nil	0·52	0·09	Nil
Shorthorn	18	0·56	Nil	0·39	0·05	Nil
Hereford × Shorthorn	10	0·45	Nil	0·55	Nil	Nil
Brahman × Shorthorn	14	0·28	Nil	0·43	0·18	0·11
Brahman × Hereford	15	0·40	Nil	0·24	0·20	0·16
Africander × Shorthorn	13	0·19	Nil	0·50	0·31	Nil
Africander × Hereford	15	0·23	Nil	0·47	0·30	Nil
Brahman*	—	0·3	Nil	0·1	0·3	0·3
Africander*	—	Nil	Nil	0·4	0·6	Nil

* Approximate frequencies computed from remainder of data.

It has been suggested previously[1,3] that the frequency of β^E within a breed may reflect the climatic or ecological stress to which the breed is subjected. Thus, the frequency of β^E increases in a northerly direction in the British Isles, both within and between breeds. The high frequency of β^E in all the zebu breeds examined is particularly interesting therefore in view of the well-known climatic and ecological tolerance of these cattle.

I thank the Officer-in-Charge of the F. D. McMaster Field Station of the Commonwealth Scientific and Industrial Research Organization, Badgery's Creek, New South Wales, and of the National Cattle Breeding Station of the Commonwealth Scientific and Industrial Research Organization, 'Belmont', Rockhampton, Queensland, for supplying blood samples, and C. Bloomfield for technical assistance.

[1] Ashton, G. C., *Nature*, **182**, 370 (1958).
[2] Ashton, G. C., and McDougall, E. I., *Nature*, **182**, 945 (1958).
[3] Ashton, G. C., *Nature*, **183**, 404 (1959).

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, November 23

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. Barrie E. Juniper: "Oxford University Tanganyika Expedition".

INSTITUTION OF MECHANICAL ENGINEERS, EDUCATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Vibration Theory, Linear Systems and the subject 'Theory of Machines' ".

Tuesday, November 24

SOCIETY FOR ANALYTICAL CHEMISTRY, PHYSICAL METHODS GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. R. A. C. Isbell: "The Design of Optical Instruments for Chemical Analysis".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Prof. D. B. Spalding: "Heat and Mass Transfer in Aeronautical Engineering".

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. N. I. Walker: "Application of Instrumentation to Glass Melting Furnaces".

RADAR AND ELECTRONICS ASSOCIATION (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.30 p.m.—Prof. H. E. M. Barlow: "Waveguides for Long Distance Communications".*

Wednesday, November 25

ROYAL SOCIETY OF ARTS (at St. John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Sir Christopher Hinton, K.B.E., F.R.S., and Sir William Holford: "Power Production and Transmission in the Countryside—Preserving Amenities".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. L. R. Raymond: "The Pre-Permian Floor beneath Billingham, Co. Durham"; Dr. J. M. Hancock: "The Cretaceous System in Northern Ireland".

INSTITUTION OF ELECTRICAL ENGINEERS, ELECTRONICS AND COMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. R. L. Smith-Rose: "Radio Aspects of the International Geophysical Year".

INSTITUTE OF PHYSICS (at 47 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. J. F. Coales: "Education for Automation".

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Prof. A. H. Cottrell, F.R.S.: "The Effect of Nuclear Radiation on Engineering Materials" (Thomas Hawksley Lecture).

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Mr. G. E. Moss: "Fortuitous Corrosion Inhibitor in Biscuit Mixes"; Mr. G. P. Seary: "Recent Developments in Produce Pre-packaging".

SOCIETY FOR ANALYTICAL CHEMISTRY (joint meeting with the PHARMACEUTICAL SOCIETY OF GREAT BRITAIN, at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Meeting on "Methods of Assays of Capsicum, Lonchocarpus and Rauwolfia".

Thursday, November 26

INSTITUTE OF MARINE ENGINEERS (joint meeting with the SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS, at the Memorial Building, 76 Mark Lane, London, E.C.3), at 3 p.m.—Mr. C. C. Pounder: "Human Problems in Marine Engineering"; at 5.30 p.m.—Mr. J. J. Zrodowski and Mr. H. C. Andersen: "Co-ordinated Alignment of Line Shaft, Propulsion Gear and Turbines".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. T. R. Manley, Mr. K. Rothwell and Mr. W. Gray: "The Application of Low-Pressure Resins to some High-Voltage Switchgear Designs".

INSTITUTION OF MECHANICAL ENGINEERS, APPLIED MECHANICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "The Application of Creep Results to Engineering Design".

ROYAL AERONAUTICAL SOCIETY (at Church House, Westminster, London, S.W.1), at 6 p.m.—Prof. H. Schlichting: "Some Developments in Boundary Layer Research in the Last Thirty Years" (Third Lanchester Memorial Lecture).

Thursday, November 26—Friday, November 27

INSTITUTE OF PETROLEUM (joint meeting with the CORROSION GROUP and the CHEMICAL ENGINEERING GROUP of the SOCIETY OF CHEMICAL INDUSTRY, in the Grand Council Chamber, The Federation of British Industries, 21 Tothill Street, London, S.W.1), at 9.30 a.m. daily—Joint Symposium on "Corrosion Problems of the Petroleum Industry".

Friday, November 27

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. D. R. Walkie: "Man and an Aero Engine".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. P. T. Haskell: "Research in the War against Locusts".

Friday, November 27—Saturday, November 28

BOTANICAL SOCIETY OF THE BRITISH ISLES (at the Lecture Hall, The British Academy, Burlington House, Piccadilly, London, W.1)—Darwinian Centenary Conference.

BRITISH SOCIETY FOR IMMUNOLOGY (at the Wellcome Foundation, 183 Euston Road, London, N.W.1)—Symposium on "Persistence of Immunity". Chairman: Dr. C. H. Andrewes.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT EXPERIMENTAL OFFICERS (2) (with a degree in agriculture or pure science with main subject zoology, or the Scottish Leaving Certificate (or equivalent) with passes in five subjects which must include English, Higher Mathematics and Science, and the ability to drive a car) in the Rodent Control Service, Department of Agriculture for Scotland—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. G388/9A (November 23).

GRADUATE ASSISTANT (with appropriate professional qualifications and/or experience) IN THE COLLEGE LIBRARY—The Principal, Royal Holloway College, Englefield Green, Surrey (November 27).

ASSISTANT LECTURER or DEMONSTRATOR (with medical qualifications registrable in this country) IN PATHOLOGY—The Registrar, The University, Manchester 13 (November 28).

READER (with a degree in chemistry and a qualification in either pharmacy or a biological subject, a research degree and experience of direction of research in medicinal chemistry) IN MEDICINAL CHEMISTRY—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (November 28).

SENIOR LECTURER and a LECTURER (preferably with a major interest in applied thermodynamics or applied mechanics, especially the theory of machines) IN ENGINEERING—The Registrar, The University, Manchester 13 (November 28).

ASSISTANT LECTURER (with special qualifications or interests in radio astronomy) IN PHYSICS—The Registrar, The University, Manchester 13 (November 30).

LECTURER IN ORGANIC CHEMISTRY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 30).

LECTURER IN PATHOLOGY in the School of Veterinary Medicine—The Registrar, Trinity College, Dublin (November 30).

LECTURER or SENIOR LECTURER IN PREVENTIVE MEDICINE at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 30).

LECTURER (preferably with teacher-training experience in West Africa or other tropical areas) IN EDUCATIONAL PSYCHOLOGY, Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (November 30).

LECTURER (with a recognized degree in agriculture) IN AGRICULTURE—The Clerk to the Governors, Essex Institute of Agriculture, Writtle, near Chelmsford, Essex (November 30).

RESEARCH ASSISTANT IN THE DEPARTMENT OF PHYSICS for work concerned with the fundamental study of electroluminescence and related processes in single crystal phosphors—The Registrar, The University, Hull (November 30).

SENIOR LECTURER (of good academic standing and with industrial and laboratory experience in electrical machinery and automatic control) IN ELECTRICAL ENGINEERING at the University of Adelaide, Australia—The Registrar, The University of Adelaide, Adelaide, South Australia (November 30).

TECHNICAL OFFICER (with a university degree or comparable qualification in physics or electrical engineering or other approved subjects) IN THE DEPARTMENT OF PHYSICS—Dr. F. B. Kipping, University Chemical Laboratory, Lensfield Road, Cambridge (December 2).

LECTURER (preferably with research interests in autecology and whole-plant physiology) IN BOTANY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (December 5).

LECTURER IN SOCIAL ANTHROPOLOGY and a LECTURER IN RURAL SOCIOLOGY IN THE FACULTY OF ECONOMIC AND SOCIAL STUDIES—The Registrar, The University, Manchester (December 12).

SENIOR LECTURER or LECTURER IN PHYSICS, and a SENIOR LECTURER or LECTURER IN INORGANIC CHEMISTRY at the University of Khartoum—The Registrar, University of Khartoum, c/o Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (December 15).

LECTURER (with an honours degree in psychology, a higher degree in psychology or equivalent qualifications) IN PSYCHOLOGY at Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 11).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN BACTERIOLOGY, BIOCHEMISTRY, BIOMOLECULAR STRUCTURE, BOTANY (Plant Biochemistry and Biophysics), CHEMICAL ENGINEERING, CHEMISTRY, CHEMISTRY OF LEATHER MANUFACTURE, CHEMOTHERAPY, COLOUR CHEMISTRY AND DYEING, ENGINEERING (Civil, Electrical or Mechanical), FUEL AND REFRACTORIES, GEOLOGY (including Geochemistry), METALLURGY, MINING (Selective Flotation and Geophysical Surveying), PHARMACOLOGY, PHYSICS, PHYSIOLOGY, OR TEXTILE INDUSTRIES (Chemistry of High Polymers (Keratin and Man-made fibres), Textile Technology and Textile Engineering)—The Registrar, The University, Leeds 2 (February 15).

CHEMIST, Scientific Officer (with an interest in animal nutrition); and AGRONOMISTS, one Senior Scientific Officer and one Scientific Officer (with an interest in pasture plant physiology, sociology and assessment in relation to the breeding of new varieties for lowland and upland conditions)—The Registrar, University College of Wales, Aberystwyth.

LECTURER IN MATHEMATICS, and a LECTURER IN STATISTICS AND MATHEMATICS—The Registrar, Bradford Institute of Technology, Bradford 7.

PHYSICIST (with several years experience with radioactive isotopes), for work upon isotopically labelled steroids—The Director, Endocrine Unit, Institute of Obstetrics and Gynæcology, Chelsea Hospital for Women, Dovehouse Street, London, S.W.3.

PLANT PHYSIOLOGIST (honours graduate with research experience) IN THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH, Palmerston North, New Zealand, to undertake research into the biochemical aspects of the physiology of plant growth and development under controlled climate conditions—The High Commissioner for New Zealand, 415 Strand, London, W.C.2, quoting Ref. No. B.11/21/13, and mentioning *Nature*.

RESEARCH ASSISTANTS (honours graduates in chemistry), to carry out research work for higher degrees in one of the following: (1) the relationship between sorption affinity of alumina for a series of organic solutes in non-polar solvents and certain physical properties of the sorptives or (2) a problem in nitrogen heterocyclic chemistry—The Principal, Derby and District College of Technology, Kedleston Road, Derby.

RESEARCH DEMONSTRATORS and RESEARCH STUDENTS IN THE DEPARTMENTS OF BUILDING AND CIVIL ENGINEERING, CHEMISTRY AND APPLIED CHEMISTRY, ELECTRICAL ENGINEERING, LIBERAL STUDIES, MATHEMATICS, MECHANICAL ENGINEERING, and PURE AND APPLIED PHYSICS—The Registrar, Royal Technical College, Salford 5, Lancs.

SENIOR TECHNICIAN IN THE MICROBIOLOGICAL LABORATORIES—The Secretary, The Royal College of Science and Technology, George Street, Glasgow, C.1.

TECHNICIAN IN THE DEPARTMENT OF BOTANY—The Registrar, University College of Wales, Aberystwyth.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The Bedfordshire Naturalist, No. 13. (Being the journal of the Bedfordshire Natural History and Field Club, for the year 1958.) Pp. 48+1 plate. (Bedford: Bedfordshire Natural History Society and Field Club, 1959.) 5*s*. [249

British Broadcasting Corporation. Engineering Division Monograph No. 26 (August 1959): Transistor Amplifiers for Sound Broadcasting. By S. D. Berry. Pp. 19. (London: British Broadcasting Corporation, 1959.) 5*s*. [249

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 939, Vol. 251 (15 September 1959): Coulomb Gauge in Non-Relativistic Quantum Electrodynamics and the Shape of Spectral Lines. By E. A. Power and S. Zienau. Pp. 427–454. 9*s*. No. 1000, Vol. 251 (15 September 1959): Propagation of Elastic Wave Motion from an Impulsive Source Along a Fluid/Solid Interface. 1: Experimental Pressure Response. By W. L. Roever and T. F. Vining. 2: Theoretical Pressure Response. By E. Strick. 3: The Pseudo-Rayleigh Wave. By E. Strick. Pp. 455–523. 23*s*. 6*d*. No. 1001, Vol. 251 (15 September 1959): On the Annual Variation of Magnetic Disturbance. By D. H. McIntosh. Pp. 525–552. 10*s*. (London: Royal Society, 1959.) [249

Ministry of Agriculture, Fisheries and Food. Fishery Investigations, Series IV. An Introductory Account of the Smaller Algae of British Coastal Waters. Part 1: Introduction and Chlorophyseae. By Dr. R. W. Butcher. Pp. ii+74+14 plates. (London: H.M. Stationery Office, 1959.) 25*s*. net. [249

Oundle School Natural History Society Report, 1958. Pp. ii+55. (Oundle, Peterborough: Oundle School Natural History Society, 1959.) [249

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Planning, Vol. 25 (28 September 1959): European Unity—a Review. Pp. 161–188. (London: Political and Economic Planning, 1959.) 3*s*. 6*d*. [309

British Medical Bulletin. Vol. 15, No. 3 (September 1959): Symposium on "Current Virus Research". Pp. 175–250+8 plates. (London: British Council, 1959.) 20*s*. [309

The Universities: a Royal Commission? By Graeme C. Moodie. (Fabian Research Series, No. 209.) Pp. 52. (London: The Fabian Society, 1959.) 5*s*. [309

Proceedings of the Royal Irish Academy. Vol. 60, Section A, No. 2: A Property of Bounded Regular Functions. By P. B. Kennedy. Pp. 7–14. 1*s*. 6*d*. Vol. 60, Section A, No. 3: On the Structure of Multiplet Σ States in Diatomic Molecules. By I. Kováca. Pp. 15–26. 2*s*. Vol. 60, Section B, No. 4: The Phytoplankton of some Irish Loughs and an Assessment of Their Trophic Status. By F. E. Round and A. J. Brook. Pp. 167–191. 3*s*. 6*d*. Vol. 60, Section B, No. 5: A Comparative Survey of the Epipelic Diatom Flora of some Irish Loughs. By F. E. Round. Pp. 193–215. 3*s*. Vol. 60, Section B, No. 6: The Silurian Rocks of the Devilsbit Mountain District, County Tipperary. By R. N. Cope. Pp. 217–242+plates 18–21. 4*s*. 6*d*. (Dublin: Hodges, Figgis and Co., Ltd., 1959.) [309

Other Countries

Cancer Current Literature Index. Vol. 1, No. 1. Pp. ii+34. Published every 2 to 3 weeks. Subscription price 7.50 dollars. (Amsterdam and New York: Excerpta Medica Foundation, 1959. Published [illegible] the American Cancer Society, Inc., New York.) [30

Annals of the New York Academy of Sciences. Vol. 79, Article [illegible] Psychophysiological Reactions to Novel Stimuli—Measurement, Adaptation, and Relationship of Psychological and Physiological Variables in the Normal Human. By Roscoe A. Dykman, William [illegible] Reese, Charles R. Galbrecht and Peggy J. Thomasson. Pp. 43–[illegible] 2.50 dollars. Vol. 80, Article 2: Hypothermia. By A. Cecil Taylor and 30 other authors. Pp. 285–550. 3.50 dollars. Vol. 81, Article [illegible] Enzymes of Polynucleotide Metabolism. By J. S. Roth and 51 other authors. Pp. 511–804. 5 dollars. Vol. 82, Article 1: Recent Contributions to Antibacterial Therapy. By Paul S. Rhoads and 54 other authors. Pp. 1–190. 2.50 dollars. (New York: New York Academy of Sciences, 1959.) [30

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Série Technique, No. 55: Comportement Physiologique du Bétail Laitier Friesland du Haut-Katanga. Par M. Jottrand, A. Lahousse et M. Vandenbranden. Pp. 61+4 photographic plates. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1959.) 50 francs. [30

Population Reference Bureau, Inc. *Population Bulletin*, Vol. [illegible] No. 6 (September 1959): Fertility of College Graduates—a College Study Postscript. Pp. 101–116. (Washington, D.C.: Population Reference Bureau, Inc., 1959.) 50 cents. [30

Heritage of Hawaii: Bernice P. Bishop Museum Annual Report for 1958. Pp. 34. (Honolulu: Bernice P. Bishop Museum, 1959.) [30

United States Department of the Interior. Geological Survey Bulletin 1046–R: Uranium in Sharon Springs Member of Pierre Shale, South Dakota and Northeastern Nebraska. By Roy C. Kepferle. Pp. iv+577–604+plates 50–53. Bulletin 1068: Geology of Wabaunsee County, Kansas. By Melville R. Mudge and Robert H. Burton. Pp. vi+210+19 plates. Bulletin 1072–C: Coal Resources of Colorado. By E. R. Landis. Pp. v+131–232+plates 2 and 3. Bulletin 1074–D: Geology of Uranium Deposits in Triassic Rocks of the Colorado Plateau Region. By W. I. Finch. Pp. iv+125–164+plates 6–10. Bulletin 1075: Bibliography of North American Geology, 1956. By Ruth Reece King. Pp. iii+554. 1.75 dollars. (Washington, D.C.: Government Printing Office, 1959.) [30

United States Department of the Interior: Geological Survey Water-Supply Paper 1400: Quality of Surface Waters of the United States, 1955. Parts 1–4: North Atlantic Slope Basins to St. Lawrence River Basin. Prepared under the direction of S. K. Love. Pp. xiii–530. 1.75 dollars. Water-Supply Paper 1401: Quality of Surface Waters of the United States, 1955. Parts 5 and 6: Hudson Bay and Upper Mississippi River Basins, and Missouri River Basin. Prepared under the direction of S. K. Love. Pp. ix+305. 1 dollar. Water-Supply Paper 1469: Ground-Water Conditions and Storage Capacity in the San Joaquin Valley, California. By G. H. David, J. H. Green, F. H. Olmsted, and D. W. Brown. Pp. viii+287+29 plates. Water-Supply Paper 1471: Hydrology of the Long Beach–Santa Ana Area, California, with special reference to the Watertightness of the Newport–Inglewood Structural Zone. By J. F. Poland. With a section on Withdrawal of Ground Water, 1932–41. By Allen Sinnott and J. F. Poland. Pp. vii+257+11 plates. Water-Supply Paper 1478: Ground-Water Resources of the Middle Big Wood River–Silver Creek Area, Blaine County, Idaho. By Rex O. Smith. Pp. iv+64+5 plates. (Washington, D.C.: Government Printing Office, 1959.) [30

United States Department of the Interior: Geological Survey Water-Supply Paper 1501: Surface Water Supply of the United States, 1957. Part 1–A: North Atlantic Slope Basins, Maine to Connecticut. Prepared under the direction of J. V. B. Wells. Pp. viii–264. 1 dollar. Water-Supply Paper 1504: Surface Water Supply of the United States, 1957. Part 2–B: South Atlantic Slope and Eastern Gulf of Mexico Basins, Ogeechee River to Pearl River. Prepared under the direction of J. V. B. Wells. Pp. x+443. 1.50 dollars. Water-Supply Paper 1513: Surface Water Supply of the United States, 1957. Part 9: Colorado River Basin. Prepared under the direction of J. V. B. Wells. Pp. xi+511. 1.75 dollars. Water-Supply Paper 1518: Surface Water Supply of the United States, 1957. Part 14: Pacific Slope Basins in Oregon and Lower Columbia River Basin. Prepared under the direction of J. V. B. Wells. Pp. ix+361. 1.25 dollars. Professional Paper 294–L: Brachiopod Fauna of Saturday Mountain Formation, Southern Lemhi Range, Idaho. By Reuben J. Ross, Jr. Pp. iii+441–481+plates 54–56. Professional Paper 317–C: Geology of Osia Mona, Puerto Rico, and Notes on Age of Mona Passage. By Clifford A. Kaye. Pp. iv+141–178+plates 12 and 13. 65 cents. Professional Paper 318: Occurrence of Nonpegmatite Beryllium in the United States. By Lawrence A. Warner, William R. Holser, V. R. Wilmarth and Eugene N. Cameron. Pp. viii+198+5 plates. 2.25 dollars. (Washington, D.C.: Government Printing Office, 1959.) [309

Transactions of the American Philosophical Society. New Series. Vol. 49, Part 5: The Anatomy of *Callimico goeldii* (Thomas): a Primitive American Primate. By W. C. Osman Hill. Pp. 116. (Philadelphia: American Philosophical Society, 1959.) 2.50 dollars. [309

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LETTERS TO THE EDITORS

Page

TERMINOLOGY

Retentate: a New Scientific Term.—E. G. Turner and J. G. Feinberg 1139

CHEMISTRY

Concentration of Stearic Acid in Monolayers Adsorbed from Solution.—George L. Gaines, jun. . 1139

A Radiochemical Tracer Study of the Relative Stability of the Halogenoplatinates.—A. J. Poë and M. S. Vaidya 1139

BIOCHEMISTRY

A New Enzyme System in the Tamarind.—D. Mukherjee and N. A. Khan 1140

A Lipoperoxidase Factor in Soya Extracts.—Dr. John A. Blain and Edward C. C. Styles . . 1141

α-Oxidation of Indoleacetonitrile.—H. F. Taylor and Prof. R. L. Wain 1142

Reaction of Formyl Porphyrins with Acetone-Hydrochloric Acid.—Dr. P. S. Clezy 1142

Pyridoxal Phosphate: a Coenzyme for Histidine Decarboxylase.—S. Ono and Prof. P. Hagen . 1143

Reaction of Mercuric Chloride with Plasmalogen.—Dr. William T. Norton 1144

Hydroxylation of Proline *in Vitro*.—Dr. M. Chvapil and J. Hurych 1145

Microbial Degradation of Rutin.—Dr. S. Hattori and I. Noguchi 1145

Chemical Nature of a Plant-Virus Inhibitor from Rice.—W. A. Jones, M. Jacobson and R. P. Kahn 1146

Release of Non-Esterified Fatty Acids from Adipose Tissue in Normal and Diabetic Rats.—Dr. J. Wenkeová and Dr. J. Páv 1147

Distribution of Enzyme Systems Responsible for Steroid Metabolism in Different Tissues and Subcellular Fractions.—Virendra B. Mahesh and Frank Ulrich 1147

An Effect of Selenium and Cystine on Lipide Peroxidation in Tissues Deficient in Vitamin E.—Dr. John G. Bieri 1148

PHYSIOLOGY

Effect of Prolonged Thyroid Administration on Aged Male Rats.—Prof. John F. Lhotka, Lloyd Glenn McArthur and Arthur A. Hellbaum . . . 1149

Blood Keto-acids in Kwashiorkor.—Prof. J. C. Edozien 1150

Effect of Acetylcholine and Eserine on the Spawning of *Hydractinia echinata*.—M. Yoshida. . . 1151

Transmission of Passive Immunity in an Insectivore.—B. Morris 1151

Release of Histamine from Rat Mast Cells by Blood Treated with Dextran.—Dr. G. T. Archer . . 1151

PATHOLOGY

Transformations of Myxoma into Vaccinia or Ectromelia Virus in Tissue Culture.—Hidesaburô Hanafusa, Teruko Hanafusa and Juntarô Kamahora . 1152

Protein Synthesis in Macrophages containing *Eimeria tenella*.—Dr. G. A. Gresham and J. G. Cruickshank 1153

Page

HISTOLOGY

Histochemical Use of the Cyanocarbon Organic Compounds.—Prof. John F. Lhotka . . . 1153

Mast Cell Population of Lung of the Guinea Pig and other Tissues.—Dr. W. G. Smith 1154

RADIOBIOLOGY

Effect of the Level of Microbial Population on Isotopically Exchangeable Phosphate in Soil.—Dr. P. Newbould and Dr. R. L. Lucas 1155

Pharmacological Suppression of Increased Capillary Permeability following Irradiation of the Intestine of Rats.—Dr. D. A. Willoughby 1156

Decrease in Radiosensitivity of the Intact Mouse Spleen Produced by Hypoxia.—Dr. L. Weiss . 1156

PALÆONTOLOGY

Conchiolin Remnants in Mother-of-Pearl from Fossil Cephalopoda.—Dr. Ch. Grégoire . . 1157

BIOLOGY

Discarded Blood Bank Blood as a Source of Protein for Cultivation of HeLa Cells.—Billy R. Blakey and Prof. George E. Gifford 1158

Age Determination in Wild Rabbits.—R. H. Taylor 1158

Asexual Reproduction in the Enchytraeidae (Olig.).—B. Christensen 1159

Variations in Early Cleavage of the Zebra Fish.—A. W. Marrable 1160

The Sea Anemone (*Calliactis parasitica*) and the Hermit Crab (*Eupaguras bernhardus*).—Dr. D. M. Ross 1161

Acanthocottus lilljeborgi (Collett) in British Seas.—P. J. Miller 1162

Defensive Acid-Secretion in Some Marine Gastropods.—Dr. T. E. Thompson 1162

Albinism in Coconut Seedlings.—Dr. K. M. Pandalai and R. V. Pillai 1163

Capsicum Species of West Africa.—C. Oyolu . . 1163

ENTOMOLOGY

Central Control of Interactions Between Behaviour Patterns in a Hemileucine Moth.—Dr. A. D. Blest 1164

Insecticidal Effects of Activated Charcoal and Clays.—S. K. Majumder, K. S. Narasimhan and V. Subrahmanyan 1165

A Simplified Method for the Culture of *Blatella germanica* under Aseptic Conditions.—R. B. Clayton 1166

Blood-feeding Habits of Adult Noctuidae (Lepidoptera) in Cambodia.—W. Buttiker 1167

MICROBIOLOGY

Effects of Deuterium Oxide on the Synthesis of *T5* and *T7* Bacteriophages.—E. L. Rothstein, L. A. Manson, R. Hartzell, jun., and David Kritchevsky 1167

Galactose-Sensitive Mutants of *Salmonella*.—Toshio Fukasawa and Horoishi Nikaido 1168

Factors in Forest-Tree Litter Extracts Affecting the Growth of Soil Micro-Organisms.—Dr. Roger Knowles and Edward Laishley 1169

FISHERIES

Prediction of Selection Factors in a Tropical Trawl Fishery.—Alan R. Longhurst 1170

NATIONAL RESEARCH COUNCIL OF CANADA
POSTDOCTORATE FELLOWSHIPS 1960–61

Approximately 100 Fellowships will be awarded for 1960–61 by the National Research Council. Of these 40 will be tenable in National Research Council Laboratories in Ottawa, Saskatoon, and Halifax, 10 in laboratories of the Canada Department of Agriculture, located at various centres, 10 in laboratories of the Canada Department of Mines and Technical Surveys in Ottawa and Victoria, 10 in laboratories of Atomic Energy of Canada Limited, and 30 in laboratories of Canadian universities.

Applicants should not be more than 35 years of age and should possess a Ph.D. degree from a recognised university, or expect to obtain such a degree before taking up an award. There are no restrictions regarding nationality of applicants, but successful candidates must meet all Canadian immigration requirements.

The annual stipend, which is free of income tax, is $3,700 for single Fellows, and $4,500 for male Fellows who are married. An allowance towards the cost of travel is also paid.

The fields in which Fellowships are available in the laboratories of the National Research Council, the Department of Agriculture, and the Department of Mines and Technical Surveys, are described in greater detail in booklets that may be obtained on request, together with application forms. Applicants who are interested in Fellowships in the universities may write directly to these institutions, or to the National Research Council for information. The fields of interest should be stated in the initial inquiry in order that appropriate information may be supplied. The closing date of the competition is February 15, 1960.

Inquiries should be addressed to:

Awards Officer,
National Research Council,
Ottawa 2, Canada,

or to the

Chief Scientific Liaison Officer,
National Research Council of Canada,
Africa House,
Kingsway, London, W.C.2, England.

BOTANIST (PLANT PATHOLOGIST)
DEPARTMENT OF AGRICULTURE UGANDA

To diagnose the cause of crop diseases and to recommend control measures: to assist with the breeding of disease-resistant crops.

Candidates must have a good Honours degree in Botany or Agricultural Botany with at least two years postgraduate experience in plant pathology.

Appointment on permanent and pensionable terms with emoluments in range £939 to £1,863 per annum or on contract/gratuity terms with gratuity of 13½% of aggregate emoluments. Free passages on appointment and leave for officer, wife and children up to three adult sea passages or four air passages.

Furnished accommodation available at low rental.

Apply stating full name, giving brief particulars of qualifications and experience to Director of Recruitment, Colonial Office, London, S.W.1, quoting Ref. No. BCD.63/9/02/C1.

SENIOR AGRONOMIST
WEST AFRICAN COCOA RESEARCH INSTITUTE, GHANA

To take charge of Agronomy Section and co-operate with senior specialist officers in the field experimental work of the Institute.

Candidates must have a degree in Agriculture or in natural science with a postgraduate diploma in agriculture and *considerable* experience in field experimentation preferably with perennial tree crops.

Appointment on contract/gratuity terms with salary in scale £2,080 to £2,650. Gratuity £12 10s. for each month of satisfactory service. Quarters with heavy furniture provided at moderate rental. Free return passages, once each tour for officer, wife and up to three children under 18 years of age. Generous leave. Free medical attention.

Apply, stating name in full and giving brief particulars of qualifications and experience, to Director of Recruitment, Colonial Office, London, S.W.1, quoting Ref. No. BCD.197/200/010/C1.

GROSS ANATOMIST REQUIRED. Excellent opportunities available for right man. Research interests preferably, but not exclusively either in electron microscopy or optical (especially interference) microscopy. Ample research funds available. Salary according to age and qualifications. Apply: Chairman, Department of Anatomy, Emory University, Atlanta 22, Georgia, U.S.A.

ASSOCIATION OF CLINICAL BIOCHEMISTS
Appointment vacant at the Queen Elizabeth Hospital, Birmingham

A vacancy exists for a BIOCHEMIST, Basic Grade, in the Biochemical Laboratory of the Queen Elizabeth Hospital.

Applicants should hold either a Science Degree of a British University or the Association of the Royal Institute of Chemistry. The salary and conditions of service are as authorised by the Whitley Council.

Applications giving details of qualifications and experience, should reach the House Governor of the Queen Elizabeth Hospital, Birmingham 15, not later than November 14, 1959.

VICTORIA UNIVERSITY OF WELLINGTON
New Zealand
SENIOR LECTURER IN CHEMISTRY

Applications are invited for the above post.

The salary for a Senior Lecturer will be £1,315 per annum, rising by annual increments of £50 to £1,615 per annum. The initial salary will be determined according to the qualifications and experience of the appointee. University salaries are at present under review. An allowance is made towards travelling expenses.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close in New Zealand and London on November 30, 1959.

VICTORIA UNIVERSITY OF WELLINGTON
New Zealand
LECTURER IN APPLIED MATHEMATICS

Applications are invited for the above post.

The salary for a lecturer will be £1,025 per annum, rising by annual increments of £50 to £1,275 per annum. The initial salary will be determined according to the qualifications and experience of the appointee. University salaries are at present under review. An allowance is made towards travelling expenses.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close in New Zealand and London on November 30, 1959.

SPACE RESEARCH

ADMINISTRATIVE ASSISTANT required by Secretariat of British National Committee on Space Research. Office situated near Baker Street Station. A male science graduate (preferably physicist) not more than 35 years old, interested in space research would find this an absorbing post. 10½ day fortnight. Pension scheme and Luncheon Vouchers. Salary according to age and experience in the range £1,000 to £1,400 per annum. Apply Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1.

NEW ZEALAND
MINISTRY OF WORKS

Investigating Officers, Town and Country Planning Branch, Wellington.

SALARY: Up to £1,100 a year.

QUALIFICATIONS DESIRED: M.A. or M.Sc., B.A. or B.Sc. preferably in Geography but applicants with these degrees in allied subjects such as Geology, Political Science, etc., would be considered.

DUTIES: Assisting in the compilation of the National Resources Survey. This Survey is intended to give a comprehensive analysis of New Zealand's resources, region by region, and the duties include research on physical, cultural and economic aspects in the various regions and the compiling of reports suitable for publication. Appointees would also be required to assist in the preparation of background material for town and country planning purposes and other investigations in relation to national, regional and local development.

Enquiries, mentioning this publication and quoting Ref. No. B.11/30/18, should be addressed to The High Commissioner for New Zealand, 415 Strand, London, W.C.2, who will furnish further details and application forms. Completed applications to be lodged in London not later than December 7, 1959.

AUSTRALIA
THE UNIVERSITY OF NEW SOUTH WALES
Vacancy for PROFESSOR OF ELECTRICAL ENGINEERING

The University invites applications for appointment to a newly created PROFESSORSHIP OF ELECTRICAL ENGINEERING in the SCHOOL OF ELECTRICAL ENGINEERING at Sydney.

Salary will be £A3,768 per annum.

The present professorial staff comprises the Head of the School, Professor R. E. Vowels and one Associate Professor.

While the area of specialisation is open, preference will be given to applicants in the field of electrical communications.

The successful applicant will be expected to take part in the administration and development of the School and to promote research and postgraduate study in his chosen field.

Subject to satisfactory medical examination, the successful applicant will be eligible to contribute to the State Superannuation Fund which provides a pension of £A1,638 per annum.

Professors are eligible for six months' study leave on full salary after three years of service, or twelve months after six years of service.

Subject to the consent of the Council of the University, they may engage in a limited amount of higher consultative work.

With the approval of the University and its bankers, married men may be assisted by loans to purchase a home.

The University reserves the right to fill the Chair by invitation.

First class ship fares to Sydney of appointee and family will be paid.

Four copies of applications together with the names of three referees and a recent photograph should be lodged with the Agent General for New South Wales, 56–57 Strand, London, W.C.2, and a copy forwarded by airmail in an envelope marked "University Appointment" to the Bursar, The University of New South Wales, Post Office Box No. 1, Kensington, New South Wales, Australia, before December 21, 1959.

CIVIL ENGINEERS
FOR DEPARTMENT OF MAIN ROADS, NEW SOUTH WALES, AUSTRALIA

Applications are invited from graduates (or undergraduates in their final year) in Civil Engineering of a recognised British or Irish University for appointment to the staff of the Department of Main Roads, New South Wales, the State Road Authority for construction of roads and bridges.

On appointment, applicants may be engaged at the Department's Head Office, Sydney, on the design of reinforced concrete and steel bridges, or on main road construction and maintenance either in the Metropolitan Area or the country.

Commencing salary according to qualifications and experience will be within the range £A1,185 to £A1,410 per annum, with annual progression, subject to technical competence to £A2,095 per annum. Appointees will be eligible to contribute to the State Superannuation Fund after six months.

Appointee's full fare from England to Australia will be met by the Department, subject to a three years' service guarantee bond being completed. Appointment will be subject to passing a medical examination and preference will be given to applicants not more than 30 years of age.

Applications should be made on forms obtainable from the Agent General for New South Wales, 56 Strand, London, W.C.2.

GOVERNMENT OF UGANDA
GOVERNMENT CHEMIST

Qualifications—Candidates (men or women) must have a first or second class honours degree in chemistry (or equivalent professional qualification) with some relevant postgraduate experience. The R.I.C. Diploma in Applied Chemistry in Branch E desirable.

Duties—To be responsible for work in the Government Chemist's Laboratory, including chemical investigations and analyses. Training of local staff and occasional travelling up-country may also be involved.

Terms of Appointment—On probation to the permanent and pensionable establishment, or on contract for one tour (30 to 36 months) in the first instance with gratuity on satisfactory completion of the engagement. Emoluments in the scale £939 to £1,863 per annum. Free passages. Quarters provided at rental if available. Hotel allowance if quarters not provided. Generous leave. Free medical attention. Taxation at local rates.

Apply to Director of Recruitment, Colonial Office, London, S.W.1. State name in full, age, qualifications and experience. Quote Ref. No. BCD.117/9/012/C1.

LETTERS TO THE EDITORS

TERMINOLOGY

Retentate: a New Scientific Term

ANYONE who has resorted to the technique of dialysis will be aware of an odd and inconvenient gap in the terminology relating to the process. For the substances which pass through the dialysis membrane there there is a generally accepted term: 'dialysate'.

Exception has been taken to this word by the editors of the *Biochemical Journal*[1]. Such exception may be justified on etymological grounds, as the purist finds unpalatable a word compounded of a Greek stem and Latin suffix. But the alternative, 'diffusate', selected by the said editors may be objectionable scientifically[2]. As dialysate has otherwise received universal acceptance and usage, it is best retained despite its hybrid origins.

On the other hand, to our knowledge, no suitable or generally accepted term exists to describe the material which is retained by semi-permeable membranes. Herbertson *et al.*[3] have recently referred to the retained material as the "core", but there seems little logic or justification for the selection of this word, which has other recognized connotations. Most authors have bridged the existing terminological gap by circumlocution, for example, the non-dialysable material, the substances which remain in the dialysis bag (tube), etc. Altogether, the situation is unsatisfactory.

After due deliberation, in which several alternative possibilities were considered, we propose the term 'retentate' to designate those substances which are retained by semipermeable membranes in the course of dialysis.

Though we recognize the term is of Latin derivation, while being applied in a process which is designated by a word derived from Greek, we feel this is less heinous than the bastardy already committed in the parentage of dialysate. We further feel retentate has the advantages of (1) ready recognition, being descriptive of the events concerned, and (2) uniqueness, inasmuch as it has not hitherto been used in any other sense.

E. G. TURNER

Institute of Classical Studies,
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J. G. FEINBERG

Bencard Allergy Research Unit,
Beecham Research Laboratories,
Betchworth, Surrey.

[1] "The Biochemical Journal Suggestions to Authors", revised 1957 p. 10.
[2] Editor, *Immunology* **2**, 1 (1959).
[3] Herbertson, S., Porath, J., and Colldahl, H., *Acta Chem. Scand.*, **12**, 737 (1958).

CHEMISTRY

Concentration of Stearic Acid in Monolayers Adsorbed from Solution

MATHIESON[1] has recently obtained electron micrographs of oleophobic stearic acid films adsorbed on mica from hexadecane solution. These show islands of stearic acid in the monolayer, with only about one-third of the surface covered. The observations are in good agreement with the results reported by Cook and Ries[2] for the adsorption of radioactive stearic acid on mica and gold from hexadecane solutions. They, too, found that only 20–30 per cent of a close-packed monolayer of stearic acid molecules was adsorbed on these inert substrates. Mathieson also points out that island structures are not formed when adsorption of stearic acid proceeds from the melt. These authors have interpreted their observations in terms of a solvent-solute interaction whereby stearic acid molecules adsorbed from solution are surrounded by hexadecane molecules in an oriented array.

We have recently found that the adsorption of radiostearic acid from nitromethane solutions leads to similar results. Oleophobic films of $C_{17}H_{35}{}^{14}COOH$ formed on mica, platinum and chrome-plated steel substrates by immersion in saturated nitromethane solutions for periods of 1 min.–2 hr. contained 0·1–0·4 of a close-packed monolayer of stearic acid. The high degree of association in liquid nitromethane (b.p. 101°C.) and the lack of correlation between the amount of stearic acid adsorption and possible adsorption sites on the solids studied suggests a solvent-solute interaction mechanism in this case, too.

These observations are being reported and discussed in more detail elsewhere[3].

GEORGE L. GAINES, jun.

General Electric Research Laboratory,
Schenectady, New York.

September 11.

[1] Mathieson, R. T., *Nature*, **183**, 1803 (1959).
[2] Cook, H. D., and Ries, H. E., jun., *J. Phys. Chem.*, **63**, 226 (1959).
[3] Gaines, G. L., jun., American Chemical Society 136th National Meeting, Atlantic City, September, 1959 (to be submitted to *J. Phys. Chem.*).

A Radiochemical Tracer Study of the Relative Stability of the Halogenoplatinates

IN view of the recent classification of metals into two types[1], partly on the basis of the relative stabilities of their halogen complexes, we wish to report the direct measurement of the relative stabilities of the chloro-, bromo- and iodo-platinates in aqueous solution. These stabilities can be used to obtain the differences of bond-strength between the various complexes. An earlier attempt by Schlesinger and

Palmateer[2] to measure the stabilities spectrophotometrically gave only semi-quantitative results.

The addition of iodide solutions labelled with iodine-131 to $PtCl_6^{2-}$: Cl^- and $PtBr_6^{2-}$: Br^- mixtures followed, after equilibrium was attained, by precipitation of the mixed complex as the cæsium salt, enabled the ratio of free to ligand iodide to be measured radiochemically. This method provides a quick and accurate analysis of small amounts of iodide, in the complex or free state, in the presence of much larger amounts of chloride or bromide. (A similar procedure has been used to study the relative stabilities of the chloro- and bromo-platinites by Dunning and Martin[3], to whom we are indebted for a preprint of their forthcoming paper). In this way, curves relating $\log \{[Cl^-] / [I^-]\}_{free}$ or $\log \{[Br^-]/[I^-]\}_{free}$ to the average number of iodide ligands in the complex were obtained at 0, 25 and 44·5° C. From each curve the six equilibrium constants for successive substitutions by iodide were derived using Bjerrum's method[4]. For the purpose of comparison, only the overall constants $K_{Cl:I}$ and $K_{Br:I}$ will be considered, where $K_{Cl:I} = [PtI_6^{2-}][Cl^-]^6/[PtCl_6^{2-}][I^-]^6$. At 25° C., $\log K_{Cl:I} = 18{\cdot}2_5$ and $\log K_{Br:I} = 16{\cdot}1_9$. The solution had an ionic strength of 0·5, but since the equilibria involve interchange of quite similar ions, it is probable that the concentration constants measured are close to the thermodynamic constants. The variation of $\log K$ with temperature leads to values of $\Delta H°$ for the total replacement, by iodide, of chloride or bromide in the complex.

For the overall reaction : $PtCl_6^{2-} + 6I^- \rightarrow PtI_6^{2-} + 6Cl^-$, $\Delta H°$ is made up by : (*a*) the difference between the total heats of hydration of the six chloride ions and the six iodide ions, (*b*) the difference between the heats of hydration of the two complex ions, and (*c*) the difference between the total heat contents of the six Pt–I bonds and the six Pt-Cl bonds. (*b*) can be calculated to be of the order of 22 kcal./gm. ion, using the Born equation[5] and a radius estimated from known bond-lengths[6] and ionic radii. (*a*) is −112 kcal. (ref. 7) and the overall measured value of $\Delta H°$ is −19 kcal. (*c*) is therefore + 71 kcal./gm. ion, and the average individual Pt–I bond is of the order of 12 kcal. weaker than the corresponding Pt–Cl bond. Similar calculations based on our $\Delta H°$ measurement show that the Pt–I bond is 4–5 kcal. weaker than the Pt–Br bond.

The value of $\Delta H°$ is therefore determined by the difference between two large terms. One, the change in heat of hydration of the system, favours the iodide as the more stable complex; and the other, the change in bond-strengths, favours the chloride. In the case of metals where the stabilities in aqueous solution of the halogen complexes are in the order I < Br < Cl, the relative bond-strengths are decisive. As the M–I bond becomes relatively less weak, the iodide complex will become relatively stronger, and when it is less than about 10–15 kcal. weaker than the M–Cl bond, the order of stability will become I > Br > Cl. The exact point of the reversal of the order of stability, as measured by equilibrium constants will, of course, depend also on entropy factors. Since platinum (IV) is a typical member of the I > Br > Cl class, it is likely that the bond-strength order is I < Br < Cl in all halogen complexes ; but, provided the inequality is not too great, the order of stability can be the reverse of this. The border-line between the two classes of metals will only fortuitously be the same, when defined by this criterion (which is highly dependent on the solvent), as when defined by the relative stabilities of uncharged group 5 or group 6 ligand atoms, where solvation effects will be much smaller.

The importance of solvation effects seems to have been first pointed out by Kazarnovskii[8] in 1943. The above treatment follows that of Grinberg and Nikol'skaya[9], who showed how it explained the apparent anomaly whereby the order of lability of platinum complexes is I > Br > Cl even though this is also the order of their thermodynamic stabilities in aqueous solutions.

A more detailed account of this work will be given elsewhere.

A. J. Poë
M. S. Vaidya
Inorganic Chemistry Research Laboratories,
Imperial College of Science and Technology,
London, S.W.7.
June 22.

[1] Ahrland, S., Chatt, J., and Davies, N. R., *Quart. Rev. Chem. Soc.*, **13**, 265 (1958).
[2] Schlesinger, H. I., and Palmateer, R. E., *J. Amer. Chem. Soc.*, **52**, 4316 (1930).
[3] Dunning, W. W., and Martin, jun., D. S., abstracts of papers, Amer. Chem. Soc., 135th meeting, April 1959, p. 52*M* ; *J. Amer. Chem. Soc.* (in the press).
[4] Bjerrum, J., "Metal Ammine Formation in Aqueous Solution", 33 (Haase and Son, Copenhagen, 1957).
[5] Born, M., *Z. Phys.*, **1**, 45 (1920).
[6] "Interatomic Distances" (Chemical Society, London, 1958).
[7] "Selected Values of Chemical Thermodynamic Properties", Circ. 500, National Bureau of Standards, Washington, D.C. (1952).
[8] Kazarnovskii, I. A., *Bull. Acad. Sci. U.R.S.S.*, **6**, 479 (1943) (quoted in ref. 9).
[9] Grinberg, A. A., and Nikol'skaya, L. E., *J. App. Chem., U.S.S.R.* **74**, 893 (1951).

BIOCHEMISTRY

A New Enzyme System in the Tamarind

A new polysaccharide has been demonstrated to be active in the seed kernel of the tamarind (*Tamarindus indica*, Linn.) during germination. It was purified as follows. The ground kernel was extracted successively by petroleum ether (b.p., 60–80°C.), chloroform and absolute ethyl alcohol. One per cent of the solution from the residues was centrifuged three times, precipitated by an equal volume of 95 per cent ethyl alcohol and filtered through linen and dried. This was repeated twice and the fibrous product extracted in a Soxhlet apparatus by absolute alcohol for more than 48 hr. The pure polysaccharide (yields, 51·0 per cent ; ash, 0·0) was shown to be homogenous by obtaining ten fractions as solutions by successive treatments of two samples with water at different temperatures, one from low to high and the other from high to low. Each fraction of solution gave the same polysaccharide which yielded on chemical hydrolysis, the same ratio of sugars (glucose, galactose, xylose : 3, 1, 2), as demonstrated by chemical and chromatographic methods. In several series of quantitative experiments of isolation, no other polysaccharide was detected in the kernel.

Neither diastase (B.D.H.) nor germinated barley malt could hydrolyze this polysaccharide at temperatures ranging from 30–70°C. ; but taka diastase (Parke-Davis) did hydrolyze it at these temperatures.

That this enzyme system differed from taka diastase, was shown as follows. Germinated seeds (20 gm.) were ground with 25 ml. distilled water in a glass mortar. The resulting slurry with 175 ml.

water was stirred mechanically for 30 min. and filtered through linen. This extract (10 ml. per sample) was allowed to hydrolyze different samples (each 25 ml.) of the taramind polysaccharide solution (0·25 per cent), at different temperatures in the range, 31–60°C., for 18 hr. The enzyme was active between 31° and 45°C., with an optimum at 38°C. and it rose to a maximum in the *p*H range, 4·0–5·0. The enzyme was found to be inactive in the dried seed, and to gain maximum activity after the seed coat was shed and before initiation of leaves. This enzyme system, hydrolytic and protein in nature, as well as not precipitable by ammonium sulphate, is also effective on starch in optimum conditions. The synthetic enzyme system could not even be found in the seeds of growing fruit from initial stages.

Further details will be published elsewhere. We wish to thank Dr. M. Qudrat-i-Khuda and Dr. Salimuzzaman Siddiqui for their encouragement.

D. Mukherjee
N. A. Khan

Division of Foods and Nutrition,
East Regional Laboratories,
Pakistan Council of Scientific and Industrial Research,
Tejgaon, Dacca.
July 1.

A Lipoperoxidase Factor in Soya Extracts

Most studies on lipoxidase have been carried out on material from soya extracts. Lipoxidase catalyses the oxidation of pentadiene fatty acids such as linoleic acid, forming conjugated diene hydroperoxides. Hæmatin compounds such as hæmoglobin, catalase and cytochrome *c* also catalyse the oxidation of these fatty acids. A recent study of this type of hæmatin action has been made by Maier and Tappel[1]. (For convenience we use the term 'hæmatins' for iron-porphyrin compounds irrespective of iron valency.)

We have been interested in determining whether extacts of soya bean and other plant materials owe some of their unsaturated-fat oxidase activity to the presence of hæmatins as well as to lipoxidase. We used cytochrome *c* as catalyst in a system previously devised as an assay for soya lipoxidase[2]. In this system the degree of oxidation of linoleate by lipoxidase is indicated by the secondary destruction of β-carotene, and the resulting colour change is a measure of lipoxidase activity. At *p*H 5·4, using freshly prepared sodium linoleate and β-carotene at levels of $0{\cdot}7 \times 10^{-4}$ *M* and $1{\cdot}1 \times 10^{-6}$ *M* respectively, in the system, there was virtually no reaction but with slightly oxidized linoleate cytochrome *c* caused considerable carotene destruction. With excess cytochrome *c* ($0{\cdot}8 \times 10^{-7}$ *M*) the bleaching was proportional to the concentration of conjugated diene between diene levels of $0{\cdot}1 \times 10^{-6}$ *M* and 4×10^{-6} *M* in the system. With an excess of conjugated diene (10^{-5} *M*), the destruction of carotene was proportional to the concentration of cytochrome *c* at levels of between 0·4 and 4×10^{-8} *M* cytochrome *c* in the system. The reaction was completed within less than a minute: no further bleaching occurred if the reaction were prolonged for several minutes. When the reaction was carried out in the absence of β-carotene and measurements of conjugated diene made at 234 mμ, a fall in the level of conjugated diene was observed.

Under the conditions described the cytochrome *c* bleaches carotene by the destruction of preformed peroxide rather than by the coupled concurrent oxidation of linoleate whereas lipoxidase causes increase of conjugated diene in the presence of β-carotene[3].

On examining defatted soya under similar conditions we found that distilled water extracts differ in nature from *p*H 4·5 acetate buffer extracts as indicated in Table 1.

Table 1. Percentage β-Carotene Destroyed in 1 min. by 0·2 ml. Soya Extract (2 gm./100 ml.)

Concentration of linoleate hydroperoxide in reaction system	Water extract	*p*H 4·5 buffer extract
Less than 6×10^{-8} *M*	74	14
6×10^{-6} *M*	78	48

These figures, typical of results obtained in many experiments, suggest that there are two factors in soya; one predominating in water extracts, little affected by preformed diene, the other, in buffer extracts more active in the presence of preformed diene. With fresh substrate in the absence of β-carotene the ratio of diene conjugation produced by the water extract to that produced by the buffer extract was about 5 : 1. This is of the order of the comparable ratio for carotene bleaching as shown in Table 1. With preformed peroxide in the system the diene conjugation ratio is not lowered while the carotene destruction ratio falls to about 1·5 : 1 as shown in the table, and may be further lowered when greater amounts of peroxidized linoleate are present.

It would appear that the buffer extracts differ from the water extracts in having more 'lipoperoxidase' activity (similar to that of cytochrome *c*) in that they use preformed linoleate peroxide to bleach β-carotene, and in consequence destroy much more of the pigment when auto-oxidized substrate is used. The water extracts appear to bleach carotene mainly by concurrent oxidation of linoleate. The activities of both extracts were destroyed by heating at 80° C. for 3 min.

In this system we find that hæmoglobin and cytochrome *c* are most active about *p*H 3·8. Hawthorn and Todd[4] observed a similar optimum for catalase. However, buffer extracts of soya have a *p*H optimum between 5 and 6 in the system. So that, while the lipoperoxidase factor resembles the hæmatins mentioned in acting on linoleate peroxide, it appears to differ in its response to hydrogen ion concentration.

A full account of this work will be published elsewhere.

One of us (J. A. B.) wishes to thank the Department of Scientific and Industrial Research for partial financial support of this work and Miss Thelma Carnegie for technical assistance.

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α-Oxidation of Indoleacetonitrile

It is known that certain plant tissues can convert 3-indolylacetonitrile to the highly active plant growth substance 3-indolylacetic acid[1-3] and we have shown that other plant tissues are able to bring about an α-oxidation of 3-indolylacetonitrile to yield 3-indolylcarboxylic acid which is inactive[3,4]. A recent publication by Thimann and Mahadevan[5] describing the extraction of what is believed to be a hydrolytic enzyme from the stems and leaves of certain monocotyledons (Gramineae), which is capable of converting 3-indolylacetonitrile to 3-indolylacetic acid, prompts us to report upon experiments using a cell-free extract of etiolated stems of a dicotyledon (*Pisum*). A clear demonstration of the α-oxidation of 3-indolylacetonitrile to 3-indolylcarboxylic acid is given by this extract.

Pea seedlings (var. Alaska) were grown at 25°C. in red light and harvested when 12 cm. in height. About 100 gm. of stems from which the terminal 5 mm. had been removed, were frozen at −15°C. and then ground at this temperature. The tissue was allowed to thaw, 25 ml. of phosphate buffer (*p*H 7·0, 0·025 *M*) added, and the crude extract strained. This extract was centrifuged in nylon tubes for 25 min. at 11,000 r.p.m. (approx. 14,000 *g*) in a refrigerated centrifuge at 2°C. The cell-free supernatant liquid was pipetted from the centrifuge tubes and used immediately for the metabolic studies. 3-indolylacetonitrile was dissolved in 0·2 per cent aqueous acetone to give a 20 p.p.m. solution. A 25 ml. quantity of this nitrile solution was mixed with 25 ml. of the cell-free extract in a 200 ml. glass stoppered tube and incubated for 12 hr. at 25°C. in darkness. The contents of the tube were then acidified to *p*H 2·8–3·1 and extracted with peroxide-free ether. The presence of 3-indolylcarboxylic acid in this extract was shown on a two-dimensional paper chromatogram developed first in *iso*propanol/ammonia (0·880)/water (10:1:1) and then in *iso*propanol/acetic acid (glacial)/water (4:1:1). After spraying the chromatogram with Ehrlich reagent, a pink spot which gave a characteristic red fluorescence in ultra-violet light slowly appeared. This chromatogram was compared with one bearing synthetic 3-indolylcarboxylic acid developed simultaneously. A comparison of the 3-indolylcarboxylic acid content of different extracts was made possible by applying the extracts to the starting line of a chromatogram which was then developed once in the ammoniacal solvent and sprayed with Ehrlich reagent to give pink spots (R_F 0·18).

In addition to showing the degradation of 3-indolylacetonitrile to 3-indolylcarboxylic acid evidence was obtained of the presence of an aldehyde (R_F 0·79) on chromatograms developed in *iso*propanol/ammonia/water and sprayed with a solution of 2:4-dinitrophenylhydrazine hydrochloride. This aldehyde was inseparable from synthetic 3-indolealdehyde by two-dimensional chromatography and it is likely that this compound, which was also found in our earlier metabolic studies[6], is an intermediate product in the conversion of 3-indolylacetonitrile to 3-indolylcarboxylic acid.

The α-oxidation of 3-indolylacetonitrile was prevented by boiling the cell-free extract for a period of 1–2 min. prior to the addition of the nitrile solution; the amount of 3-indolylcarboxylic acid found in the ether extract was then no greater than the trace normally found in extracts of pea tissue. The natural occurrence of ether extractable 3-indolylcarboxylic acid in pea tissue has previously been reported[7]. Considerably reduced amounts of it were produced from 3-indolylacetonitrile when the enzyme inhibitors, iodoacetate and phenyl mercuric nitrate, were added to the solutions before incubation, and these indications that sulphydryl groups may be involved in the α-oxidation are being further investigated.

By subjecting the cell-free extract to increasing concentrations of ammonium sulphate at *p*H 7·0, a series of precipitates was obtained, one of which contained most of the enzyme activity. This active fraction, which was precipitated when the ammonium sulphate concentration of the extract was raised from forty per cent to sixty per cent saturated, was readily redissolved in phosphate buffer for metabolic studies. Since a quantity of material was precipitated at ammonium sulphate concentrations below forty per cent saturated, this procedure proved to be a useful purification method.

Whilst the efficiency of conversion of 3-indolylacetonitrile to 3-indolylcarboxylic acid was greatly increased by using this purified preparation, there was still no evidence on the chromatograms for the production of 3-indolylacetic acid. This confirms the work of Thimann[1] and Seeley *et al.*[3] and is in marked contrast to the behaviour of 3-indolylacetonitrile in wheat and maize coleoptiles[2] and with enzyme extracts of *Avena* and *Hordeum* tissue[4] where conversion to 3-indolylacetic acid readily occurs.

All these results correlate well with those of biological tests; thus, for example, 3-indolylacetonitrile is highly active at low concentrations as a plant growth substance in tests using the coleoptiles of Gramineae, but at these concentrations is completely inactive in tests using pea tissue[1,3,8].

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Reaction of Formyl Porphyrins with Acetone-Hydrochloric Acid

Acetone-hydrochloric acid has been widely used to split hæmoproteins, including cytochromes of the *a* type which contain formyl substituents in their prosthetic groups. Results reported below show that formyl porphyrins and hæmins react with acetone-hydrochloric acid, and hence it is necessary to exercise caution in the use of this reagent. Fortunately the reaction between formyl porphyrins

and acetone-hydrochloric acid is a slow one (48–72 hr. being necessary for complete conversion at room temperature) so that if the temperature is kept low and only a relatively short time is allowed for cleavage of hæmoprotein the amount of alteration of a formyl group is negligible.

A small amount of the porphyrin under investigation was allowed to stand at room temperature, in the dark, in acetone containing 0·7 per cent (w/v) hydrochloric acid, any change in the spectroscopic properties of the porphyrin being noted by alteration of the position of the absorption bands. When the reaction was completed, as evidenced by the constant position of these absorption bands, the porphyrin was returned to ether, and the reaction product purified by alumina chromatography of the methyl ester. Paper chromatography, according to the method of Chu, Green and Chu[1], showed that the product was homogeneous.

This reaction was carried out with five formyl porphyrins (monoformyl- and diformyl-deuteroporphyrin, chlorocruoroporphyrin, porphyrin *a*[2], and cryptoporphyrin *a*[3]), and with monoacetyl- and diacetyl-deuteroporphyrin. All the formyl porphyrins were shown to react with acetone-hydrochloric acid while the acetyl porphyrins were recovered unchanged from the reaction mixture. It was also established that the use of iron complexes instead of the free porphyrin did not alter the result of the reaction. The absorption maxima of the acetone condensates of the formyl prophyrins are recorded in Table 1 together with the corresponding data for the parent formyl porphyrin.

Although aldol condensations are usually associated with alkaline *p*H's, it is known that similar type condensations can occur under acidic conditions[4], and this seems to offer a probable explanation of the reaction of acetone-hydrochloric acid with formyl porphyrins. Thus the reaction might be summarized as:

$$-CHO + CH_3COCH_3 \rightarrow -CH=CH-CO-CH_3 + H_2O$$

and such an alteration is in accord with observed spectroscopic properties of the resulting porphyrins. Further evidence in support of this explanation has been obtained by the treatment of the acetone condensate of monoformyl-deuteroporphyrin with sodium hydroxide-iodine (iodoform reaction) from which reaction monoacrylic acid deuteroporphyrin has been obtained. The identity of this degradation product was established by comparison of its trimethyl ester with an authentic sample of this compound. Both samples had the same R_F value in two solvent systems[1], and had identical visible spectra (Table 1).

TABLE 1

Porphyrin	Absorption Bands mμ I	II	III	IV	III/IV
Monoformyl deuteroporphyrin	641	578	555	515	1·70
Acetone condensate of	637	575	551	510	1·49
Diformyl deuteroporphyrin	648	593	562	525	0·64
Acetone condensate of	643	587	557	519	1·06
Chlorocruoroporphyrin	642	583	559	519	1·36
Acetone condensate of	639	581	555	514	1·22
Cryptoporphyrin *a*	642	584	559	519	1·30
Acetone condensate of	639	582	555	515	1·24
Porphyrin *a*	646	582	558	517	2·30
Acetone condensate of	645	579	555	512	1·88
Synthetic monoacrylic acid deuteroporphyrin trimethyl ester	636	574	544	505	1·24
Degradation product from acetone condensate of monoformyl deuteroporphyrin	636	575	544	505	1·13

With the exception of porphyrin *a*, its condensate and the two samples of monoacrylic acid deuteroporphyrin where ether was the solvent used, all spectroscopic data were determined in chloroform solution.

I would like to thank Dr. R. Lemberg for his encouragement and advice and Mr. J. Barrett for a sample of monoacrylic acid deuteroporphyrin trimethyl ester. A grant from the National Health and Medical Research Council of Australia is gratefully acknowledged.

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Pyridoxal Phosphate: a Coenzyme for Histidine Decarboxylase

ALTHOUGH the role of pyridoxal phosphate as a coenzyme of amino-acid decarboxylases is generally recognized, attempts to demonstrate its participation in the enzymic decarboxylation of histidine have hitherto been unsuccessful.[1]

We have been able to demonstrate an activation of mastocytoma histidine decarboxylase by pyridoxal phosphate. The enzyme source was the supernatant fraction obtained by centrifugation of a 1 in 2 homogenate of mouse mastocytoma[2] in 0·3 *M* sucrose at 140,000 *g* for 2 hr. followed by dialysis for 60 hr. at 0° C. against frequently changed distilled water. Dialysis served to remove not only pyridoxal phosphate but also histamine and other amines present in this tissue.

Tubes containing 0·3-ml. samples of enzyme solution were incubated at 37° C. in 0·2 *M* phosphate buffer at *p*H 7 with several different concentrations of *l* (–) histidine (70, 140, 280, 560 μgm./ml.) both with and without the addition of 30 μgm./ml. of pyridoxal phosphate. The total volume of incubation mixture in each tube was 1·5 ml.; 0·3 ml. samples were removed at 1, 60 and 120 min. after beginning the incubation, and acidified to stop the reaction. After neutralization the samples were diluted with Locke solution and the histamine content of each sample was estimated by bioassay on a strip of isolated guinea-pig ileum suspended in Locke solution.

The results of a typical experiment are shown graphically (Fig. 1).

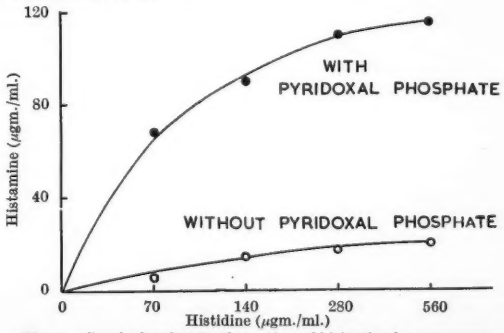

Fig. 1. Graph showing the formation of histamine by a preparation of mouse mastocytoma tissue incubated in the presence of different concentrations of *l*(-)histidine with and without the addition of pyridoxal phosphate.

This experiment has been repeated a number of times with the same result, namely that after prolonged dialysis pyridoxal phosphate must be added to the incubation medium for full activity of the enzyme to be observed. On the other hand, after dialysis for less than 24 hr., adequate to remove the amines, full or almost full activity of the enzyme can be observed without the addition of pyridoxal phosphate[2].

This investigation was supported by U.S. Public Health Service research grant No. *B*–1470 from the National Institute of Neurological Diseases and Blindness and Grant No. *C*–2547 from the National Cancer Institute.

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Reaction of Mercuric Chloride with Plasmalogen

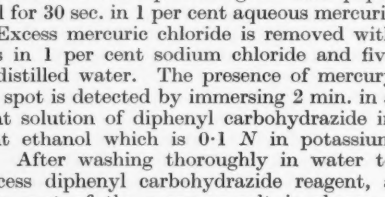
It has been found that aqueous mercuric chloride reacts with the enol-ether double bond of plasmalogen[1] to form a mercury-organic compound. This reaction clarifies the mercuric chloride catalysis in the Feulgen-Voit-Schiff identification of plasmalogen[2].

Filter paper is spotted with 70 μgm. (2 μl. of solution) of a commercial preparation of beef heart lecithin ('Lecithin' (ex beef), Sylvana Chemical Co., Orange, New Jersey) in 95 per cent ethanol which assays 52 per cent choline plasmalogen. This paper is immersed for 30 sec. in 1 per cent aqueous mercuric chloride. Excess mercuric chloride is removed with five washes in 1 per cent sodium chloride and five washes in distilled water. The presence of mercury in the lipid spot is detected by immersing 2 min. in a 0·1 per cent solution of diphenyl carbohydrazide in 70 per cent ethanol which is 0·1 *N* in potassium hydroxide. After washing thoroughly in water to remove excess diphenyl carbohydrazide reagent, a deep purple spot of the mercury salt is observed against an unstained background. This test is sensitive to 1·0 μgm. of plasmalogen in a spot of 1 cm. diameter. Other agents for detecting mercury may be used, for example hydrogen sulphide or dithizone, but these are less sensitive.

The following lipids were tested by the same technique and were found to be negative: sphingomyelin, cerebroside, cholesterol, strandin, oleic acid, linoleic acid, linolenic acid, stearic acid, methyl oleate, myristic aldehyde, linseed oil and olive oil.

The site of reaction of mercuric chloride with the lecithin-plasmalogen mixture was determined in the following ways. A negative reaction means that no formation of the mercury-diphenyl-carbazide salt was detected in the lipid spot.

(*A*) When the beef heart lecithin-plasmalogen mixture was treated either (1) by hydrolysis in 90 per cent acetic acid[3], 1 hr. at 50°C. or (2) by hydrogenation with platinum oxide, 1 hr. at 50°C., and the total products spotted on filter paper, the mercuric chloride reaction carried out as described above was negative.



(III)

(*B*) Filter papers after being spotted with the beef heart lecithin-plasmalogen mixture were subjected to the following separate treatments:

(1) 0·1 *N* aqueous iodine, 2 min. at 25°C.
(2) 0·1 *N* hydrochloric acid, 1 hr. at 50°C.
(3) 0·1 *N* aqueous bromine in 2 per cent potassium bromide, 2 min. at 25°C.

After a thorough water wash the papers were treated with mercuric chloride and then with diphenyl carbohydrazide as described above. In each case the reaction was negative.

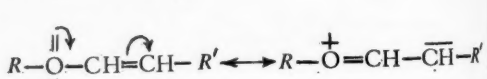
(*C*) Filter papers spotted with the beef heart lecithin-plasmalogen mixture and treated with 1 per cent mercuric chloride were then subjected to the following separate treatments:

(1) 5 per cent potassium cyanide, 5 min. at 25°C.
(2) 0·1 *N* aqueous iodine, 5 min. at 25°C.
(3) 0·1 *N* hydrochloric acid, 5 min. at 25°C.

In each case a negative reaction was obtained with diphenylcarbohydrazide.

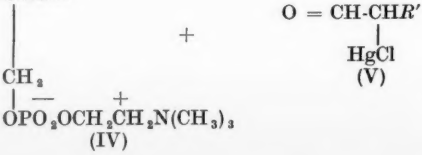
All the above series of reactions have been duplicated on a chloroform-methanol extract of total rat brain lipids[4] which contains plasmalogens to the extent of 10 per cent of the total lipids.

These reactions are consistent with the view that the mercuric chloride is reacting with a double bond which is labile to acid hydrolysis and mild iodine treatment. The mercuric chloride adduct formed is labile to acid and mercuric complexing agents. The reaction of mercuric chloride with the enol-ether of plasmalogens is analogous to the reaction of more ionic mercury salts with normal olefins[5]. Mercuric chloride reacts slowly or not at all with simple olefins[5], probably because of the low concentration of $HgCl^+$ ions. The resonance form (II), of the enol-ether structure increases the negative charge on the β-carbon making it much more reactive to electrophilic additions of this type:



(I) (II)

Preliminary quantitative studies of the uptake of mercury in lipid spots indicate that the reaction with the α, β-unsaturated ether is almost instantaneous. However, after about 60 sec. in 1 per cent mercuric chloride a slow reaction with other unsaturated bonds begins. If the product of the mercuric chloride catalysis of the Feulgen-Voit-Schiff reaction[2] initially formed is the hemiacetal (III), this exists in equilibrium with the free aldehyde (V), and lysolecithin:



(IV) (V)

This hypothesis has been verified by the chromatographic identification in the products of the plasmalogen-mercuric chloride reaction, of a free fatty aldehyde containing mercury and lysolecithin. Also we have isolated in 21 per cent yield β-chloromercuriacetaldehyde[6] from the reaction of the model system, butyl vinyl ether plus aqueous mercuric chloride.

This reaction with mercuric chloride has been developed for histochemical localization of plasmalogen (unpublished work).

This work was supported by U.S.P.H.S. Research Grant B1006(C4) and Interdisciplinary Grant 2M-6418(C2) N.I.M.H.

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Hydroxylation of Proline *in Vitro*

WHILE carrying out a study of hydroxyproline synthesis in biological media, by hydroxylation of proline or peptides containing proline, we have also investigated the possibility of hydroxylation of pyrrolidine ring *in vitro*. We commenced our study by ascertaining[1,2,3] whether or not cortisone inhibited the formation of free hydroxyproline in animal tissues during their embryonal development and thus interfered with the biosynthesis of collagen.

The possibility of incorporating free hydroxyproline[4,5] (and hydroxylysin in analogy[6,7]), into collagen proteins was denied in most papers. However, in a recent study by Mitoma *et al.*[8], on the same experimental material as in our case, proofs are presented that bound hydroxyproline also originates from free hydroxyproline. Furthermore the central significance of hydroxylation of proline for the synthesis of collagen arises in the papers of Robertson[9,10] and Gould[11] who have found proof for hydroxylation inhibition of proline in the case of ascorbic-acid deficiency. The possibility of hydroxylation of both aromatic[12] and sterol rings[13] has been proved by many authors.

Our experiments have shown that in the reactive medium containing ethylene diamine tetraacetic disodium salt, Fe^{++}, ascorbic acid, hydrogen peroxide and proline, a substance forms which can be determined by specific reaction on hydroxyproline[14]. By means of paper ionophoresis, partition chromatography, as well as by isolation of hydroxyproline in the form of reineckate and by measuring the absorption curves, we have found that the substance formed has properties inherent to hydroxyproline. Hydroxylation does not occur either in the absence of ascorbic acid or hydrogen peroxide; ethylene diamine tetraacetic disodium salt and Fe^{++} are not essential, but in their presence, however, hydroxylation becomes more intensive.

Hydroxylation is almost completed within three minutes; if the incubation lasts for more than 30 min. the amount of hydroxyproline formed decreases. The presence of pure oxygen in the reactive medium, instead of hydrogen peroxide, also brings about the formation of hydroxyproline; however, the reaction rate is slow and not intensive.

We have found that the optimal concentration of substances in the reactive medium and the optimal conditions of reaction are: 8×10^{-3} *M* ferrous sulphate, $2{\cdot}6\times10^{-3}$ *M* ethylene diamine tetraacetic disodium salt, 8×10^{-3}–1×10^{-2} *M* ascorbic acid, $4{\cdot}7\times10^{-2}$ *M* hydrogen peroxide, 0·1–0·15 *M* solution of phosphate buffer, *p*H in the range 4·5–5·6. There is a definite relationship between the temperature and degree of hydroxylation (studied up to 55°C.). The amount of hydroxyproline formed is related to the concentration of proline in the reactive medium and the degree of conversion is in the region of 2–4 per cent. We have also studied the possibility of hydroxylation of prolylglycine and prolylglutamylglycine and have found the same degree of conversion as in proline.

Thus we have been able to show that in the reactive medium, of the same composition as was used before by Udenfriend *et al.*[12] for the hydroxylation of the substituted aromatic ring, hydroxylation of proline also occurs.

Further experiments aiming at the biological utilization of these results are being carried out.

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Microbial Degradation of Rutin

COMPARATIVELY little work on the metabolism of rutin has been published. 3,4-dihydroxyphenyl acetic acid and homovanillic acid are found in urine after oral administration of rutin to the rat[1,2], and protocatechuic acid accumulates in rat kidney homogenates in the presence of quercetin[3].

We have shown[4] that a fungus, *Pullularia fermentans* var. *candida*[5], forms phloroglucinol, protocatechuic acid and an unknown substance when cultivated in aqueous rutin solution. This unknown substance has now been identified as 2-protocatechuoyl phloroglucinol carboxylic acid.

The organism (about 50 mgm. wet-weight) was incubated with rutin (1 gm.) in 1 l. of 0·003 *M* phosphate buffer (*p*H 6·0) at 25°C. for 5 days, and the liquid was extracted with ether. After removal of ether, the remaining mass was dissolved in hot water (60°C.), and about 0·1 gm. substance was obtained in white needles after cooling in a refrigerator. When subjected to paper chromatography, the R_F value of this substance agreed well with that of the unknown

substance, as was reported previously, both in *n*-butanol/acetic acid/water (4:1:2) and in 80 per cent phenol.

This substance, after recrystallization from hot water, contained 2·5 mol. of water of crystallization and melted, effervescing at 174°C., and produced dark green dyes and red orange dyes with ferric chloride and with benzidine diazo reagents[6], respectively.

When hydrolyzed with 10 per cent potassium hydroxide, the substance gave phloroglucinol and protocatechuic acid and it dissolved in a sodium bicarbonate solution evolving carbon dioxide, suggesting the presence of a carboxylic group in its molecule. These facts suggest that this substance is identical with a protocatechuoyl phloroglucinol carboxylic acid (anal.: calc. for $C_{14}H_{10}O_8.2{\cdot}5H_2O$: C, 47·87; H, 4·30; found: C, 48·44; H, 4·39).

Since this substance easily loses the carboxyl group on heating to 100°C., it was methylated with an excess of diazomethane and the methyl ether methyl ester was obtained as colourless needles, which melted at 144°C. after recrystallization from absolute alcohol (anal: found: C, 60·91; H, 5·16). When admixed with 2-veratroyl 4, 6-dimethoxyphloroglucinol carboxylic acid methyl ester (anal.: calc. for $C_{19}H_{20}O_8$: C, 60, 63; H, 5·36; found: C, 60·69; H, 5·02), which had been synthesized from 2, 4-dimethoxyphloroglucinol carboxylic acid methyl ester and veratroyl chloride, this methyl ether methyl ester did not show any depression of melting point, suggesting the identity of these substances.

From these results it is evident that the substance produced by the fungus is identical with 2-protocatechuoyl phloroglucinol carboxylic acid.

We are grateful to Mr. M. Yoneyama, Biological Laboratory, University of Hiroshima, for identifying the fungus and to Dr. M. Hasegawa, Government Forest Experiment Station, for his helpful advice.

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Chemical Nature of a Plant-Virus Inhibitor from Rice

The inhibition of tobacco mosaic virus infection of primary bean leaves (*Phaseolus vulgaris* L. var. Pinto) by extracts of various portions of rice plants has been described recently[1]. The inhibitor or inhibitors present in rice resemble those derived from other plants such as spinach (*Spinacea oleracea* L.)[2], poke weed (*Phytolacca acinosa* Roxb. var. *esculenta*)[3], New Zealand spinach (*Tetragonia expansa* Murr.)[4], and sweet william (*Dianthus barbatus* L.)[5], in that the infection of test plants is inhibited when the plant extract and virus inoculum are mixed and applied simultaneously. The inhibitor in rice extracts differs in that it protects bean leaves against tobacco mosaic virus infection even when applied to the leaves (which are then rinsed with water) 1–3 days prior to inoculum application. In so far as we are aware, the only other plant extracts that protected test plants against virus infection were derived from carnation (*Dianthus caryophyllus* L.)[6], but the time between inhibitor application and inoculation was only 1–3 hr.

Experiments were conducted to determine the general chemical nature of the inhibitor as a basis for subsequent more detailed chemical investigation. The source of the inhibitor used was rice polish, since the inhibitor is concentrated in this readily available by-product in the milling of rice. The antiviral activity of the various chemical fractions of rice polish was determined by the local-lesion bioassay described by Holmes[7]. In these assays one member of each pair of opposite primary bean leaves was rubbed with the preparation plus tobacco mosaic virus and the opposite member with a comparable untreated control inoculum.

The inhibitor could be extracted from the polish with water, but not with methanol, and addition of methanol to the water extract caused complete inactivation with the formation of a precipitate. Centrifugation of the cloudy aqueous extract at 15,000 r.p.m. for 30 min. gave a clear, slightly yellow solution retaining all its activity. Addition of 20 per cent trichloroacetic acid to a final acid concentration of 10 per cent in the extract completely destroyed the activity of the inhibitor, with the formation of a slight precipitate. Addition of cold saturated ammonium sulphate solution to cold rice-polish extract to 80 per cent saturation, followed by centrifugation, gave a precipitate that was found to be active. Very slow addition of cold absolute ethanol to cold rice-polish extract, to give a final ethanol concentration of 40 per cent, followed by centrifugation, gave an active precipitate. By mixing the aqueous extract with various powdered adsorbents, it was found that the inhibitor was adsorbed on alumina, magnesium oxide ('Sea Sorb'), and charcoal, but not on silica ('Celite'). The inhibitor failed to pass through a Visking membrane in 4 hr. after the extract was placed in a stainless steel ultrafiltration apparatus and 40 lb. of nitrogen per square inch was applied.

These preliminary experiments indicate that the virus inhibitor in rice polish is probably a protein, with a molecular weight greater than 13,000.

The aqueous extract of rice polish loses its activity slowly upon standing, even at 5–7° C., with the formation of a precipitate which may be denatured protein. The fresh extract is approximately neutral in reaction, but on standing, either in the cold or at room temperature, it becomes acidic, with consequent loss in activity.

Further investigation of this virus inhibitor is in progress.

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Release of Non-Esterified Fatty Acids from Adipose Tissue in Normal and Diabetic Rats

FROM a number of recent papers it appears that the mobilization and transport of fat from fat depots to sites of its further utilization take place mostly in the form of non-esterified fatty acids[1]. Evidence that this is so is provided by Dole[2] and Gordon[3] who observed during states with an inadequate utilization of carbohydrates an elevated blood level of non-esterified fatty acid. When the utilization of carbohydrates was increased (after ingestion of glucose or after administration of insulin) the blood level of non-esterified fatty acids decreased. Experiments with adipose tissue *in vitro* also confirmed that under certain conditions non-esterified fatty acids can be released. The amount released depends on whether at the moment the animal was killed the energy requirements were satisfied from reserves. Gordon and Cherkes[4] have demonstrated an increased release of non-esterified fatty acids from incubated epididymal fat of fasting rats, while during satiety the release was insignificant. It was also revealed that the release of non-esterified fatty acids from incubated adipose tissue of normal animals is increased by various hormones added in *vitro*: adrenalin[4], noradrenalin, corticotropin[5,6], while its release is arrested after the addition of insulin[4]. Thus, it can be assumed that the adipose tissue of diabetic animals, which must mobilize fat reserves, will also, *in vitro*, release more non-esterified fatty acids than the tissue of healthy animals. Our experiments confirm this assumption.

For our experiments we used intact white rats and rats with alloxan diabetes weighing 100–120 gm. The animals were killed after 16 hours fasting and a slice of about 50 mgm. of epididymal fat was incubated for four hours in 4 ml. of pooled post-absorptive human serum at 37° C. with constant agitation. The initial and final concentration of non-esterified fatty acids in the medium was estimated using Dole's method[2], the blood sugar level by Hagedorn and Jensen's method. The results are expressed in micro-equivalents of non-esterified fatty acids released after 1 hour per 1 gm. of fresh tissue ± standard error.

We performed two separate experiments under the same conditions. In the first experiment, however, we used diabetic rats 8 days after the administration of alloxan, in the second experiment rats 15 days after the administration of alloxan, the human serum used as medium being from a different group of donors. From the tissue of the control animals in the first experiment 2·32 ± 0·31 μequiv. non-esterified fatty acids were released during the incubation, while in the diabetic rats the corresponding figure was 4·67 ± 0·41 μequiv. In the second experiment we obtained the following results: control animals 5·21 ± 0·51 μequiv. non-esterified fatty acids, diabetic animals 8·58 ± 0·52 μequiv. non-esterified fatty acids. The blood sugar level of the diabetic rats was 170–340 mgm. per cent immediately before the beginning of the experiment, of the control animals 70–110 mgm. per cent. The results are shown in Table 1.

From these experiments it appears that in animals with alloxan diabetes the release of non-esterified fatty acids from the adipose tissue is significantly higher. In earlier experiments we established the direct correlation between non-esterified fatty acids' level and blood sugar level in diabetic animals[7]. In the experiments carried out during the present work, however, no relation between the release of non-esterified fatty acids from the tissue and the blood sugar level in the alloxan diabetic animals was confirmed. To elucidate the mechanism of the difference of non-esterified fatty acids, release from adipose tissue in normal and alloxan diabetic rats it will be necessary to direct attention to changes in the tissue lipoprotein lipase activity; this being the object of our current work.

Table 1. NON-ESTERIFIED FATTY ACIDS RELEASED FROM FATTY TISSUE OF NORMAL AND ALLOXAN DIABETIC RATS

Experiment No.	Group	Number of rats	Non-esterified fatty acids production μequiv./gm. tissue/hr. Mean ± S.E.	Statistical significance
1	Control	12	2·32 ± 0·31	$P < 0·001$
	Diabetic	8	4·67 ± 0·41	
2	Control	8	5·21 ± 0·51	$P < 0·001$
	Diabetic	8	8·58 ± 0·52	

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Distribution of Enzyme Systems Responsible for Steroid Metabolism in Different Tissues and Subcellular Fractions

FROM their studies of the *in vivo* metabolism of various biologically active and inactive 11-oxygenated steroids, Bush and Mahesh[1] believe that the glucocorticoid activity of these steroids is due to the specific interaction of an 11β-hydroxy group on the steroid molecule with the receptor sites for such hormones, and that such an interaction does not involve oxidation-reduction at C–11. However, Talalay and co-workers[2] observed that various hydroxy-steroids, including the 11-oxygenated ones, can act as coenzymes in the transfer of hydrogen between pyridine nucleotides in the presence of suitable steroid dehydrogenases and they suggest that this is the mode of action of steroid hormones. In the present study, the metabolism of cortisol and cortisone has been investigated in various tissues in order to determine the distribution of enzyme systems responsible for the metabolism of the steroids, with the view of finding out whether steroid metabolism is directly involved in hormone action or whether it represents stages in their detoxication and removal from the body.

The diaphragm of the unfasted male albino rat was the first tissue to be studied. One gram of the tissue was incubated with 100 μgm. of cortisol in 10 ml. of Krebs-Ringer-phosphate buffer (*p*H 7·0–7·1) at 37·4° C. for two hours in an atmosphere of 100 per cent oxygen, and the steroids were extracted and then chromatographed on paper according to the methods described by Bush and Mahesh[3] with minor modifications.

Steroid metabolites were detected and estimated using blue tetrazolium reagent for α-ketolic compounds,

sodium hydroxide fluorescence for Δ^4-3-ketosteroids and Zimmerman's reagent for 17-ketosteroids.

Since there was very little metabolism in the diaphragm, even in the presence of 5×10^{-4} *M* triphosphopyridine nucleotide, the study was extended to rat heart, leg muscle, brain, stomach, small intestine, large intestine and kidney. In these tissues, with the exception of the kidney, there was very slight reduction at C–20 and oxidation at C–11, even with the addition of triphosphopyridine nucleotide or reduced triphosphopyridine nucleotide, and no detectable amounts of ring *A* reduced C–21 steroids or 17-ketosteroids were found. In the kidney, the main metabolites of cortisol were cortisone, 11β : 17α : 20 : 21-tetra-hydroxy-pregn-4-en-3-one and 17α : 20 : 21-trihydroxy-pregn-4-en-3 : 11-dione.

In the kidney, slices were most active in metabolism, mince was intermediate, and homogenate was the least active. In two experiments, the average C–20 reduction in slices, mince and homogenate was 48·2, 26·5 and 1·8 per cent respectively of the total recovered metabolites, whereas oxidation in the 11-position was 62·5, 46·7 and 22·2 per cent respectively. The losses of activity in the mince and homogenate were only partly recovered by the addition of triphosphopyridine nucleotide or reduced triphosphopyridine nucleotide. Schneider and Horstmann[4] also observed a similar loss of metabolic activity in liver and kidney mince as compared to the respective slices.

In order to investigate further the different metabolic activities of the various kidney preparations, the distribution of the enzyme systems in various subcellular fractions was studied. Nearly all of the oxidation of cortisol at C–11 occurred in the particulate fraction when the homogenate was centrifuged at 104,000 *g* for 1 hour. When the whole homogenate was separated by differential ultracentrifugation into nuclear particles, mitochondria, microsomes and supernatant fractions, the activity was mainly associated with the nuclear particles and microsomes, and there was very little activity in the mitochondria. There was a 13-fold increase in the amount of cortisone formed when 100 μgm. of cortisol was incubated with the nuclear fraction obtained from 1 gm. of kidney in the presence of 5×10^{-4} *M* triphosphopyridine nucleotide. In two experiments, the average amount of cortisone formed from 100 μgm. of cortisol was 38·8 μgm. in the nuclear fraction, 8 μgm. in the mitochondria and 20·5 μgm. in the microsomes.

In order to determine whether the nuclei were responsible for the metabolism of cortisol by the kidney nuclear fraction, these particles were isolated by the method of Dounce[5]. The nuclei exhibited very little metabolic activity as compared to the whole nuclear fraction. The part of the nuclear fraction remaining after removal of the nuclei, and presumably consisting mainly of cell membranes, was highly active in metabolism. This would suggest that the enzyme responsible for C–11 oxidation is linked with the cell membranes and is destroyed partly by destruction of the cell structure.

When cortisone was incubated with various kidney preparations and cell fractions, the main metabolic reaction was reduction in the C–20 position which took place to a much greater extent than with cortisol. Furthermore, in the presence of reduced triphosphopyridine nucleotide, reduction at C–11 appeared to be less than 10 per cent as compared to a 60 per cent oxidation of cortisol to cortisone in the presence of triphosphopyridine nucleotide. This would indicate that the enzyme system is not freely reversible, a property which was not observed in the corresponding liver enzyme described by Hurlock and Talalay[6].

A detailed report of this investigation will be presented elsewhere. This work was supported in part by grants from the American Cancer Society and the National Institute of Arthritis and Metabolic Diseases.

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An Effect of Selenium and Cystine on Lipide Peroxidation in Tissues Deficient in Vitamin E

Two vitamin E deficiency syndromes in the chick are preventable by nutrients other than α-tocopherol. Exudative diathesis does not occur when the deficient diet contains trace amounts of selenium. With diets simultaneously low in tocopherol and sulphur amino-acids, muscular dystrophy occurs which can be prevented by cystine, methionine, or vitamin E; trace amounts of selenium (<0·5 p.p.m.) are ineffective. The mechanism by which selenium and sulphur amino-acids replace vitamin E is unknown. Since the only established biochemical action of tocopherol is that of an antioxidant, it appeared that possibly these other nutrients may in some way affect peroxidation of unsaturated fatty acids. Thiobarbituric acid has been shown to be a sensitive reagent for determining the extent of peroxidation in autoxidizing tissues[1,2]. Using this test as described by Tappel and Zalkin[3], we have found that dietary selenium and cystine significantly reduce peroxidation in certain tissues of vitamin E-deficient chicks.

Day-old chicks were fed either of two vitamin E-deficient diets for 28 days. Diet *A* contained 30 per cent of purified soybean protein, 6 per cent of salts, 1 per cent of 'stripped' lard, 0·3 per cent of cystine, and all vitamins except E. Diet *B* contained 15 per cent of purified casein, 10 per cent of gelatin, 4 per cent of lard, 6 per cent of salts, and all vitamins except E. Glucose, to make 100 per cent, was the carbohydrate in both diets. Control groups on each diet received α-tocopherol in the diet. Diet *B*, which was low in sulphur amino-acids, produced white muscle striations in all chicks. The extent of peroxidation in liver and breast muscle homogenates was determined as indicated in Table 1. Three separate experiments with each diet gave similar results; the data from one typical experiment are shown in Table 1.

Tissues from chicks fed either diet *A* or *B* with vitamin E gave no pink colour with thiobarbituric acid when incubated alone or with ascorbic acid[2]. The low values given for these groups (3 and 6) represent faint yellow solutions uncorrected for the reagents. Aliquots of homogenates from vitamin E-deficient livers or muscles, before incubation, gave faint colours with thiobarbituric acid which were predominantly yellow. After incubation, bright pink or red colours were formed with thiobarbituric acid.

Table 1. PEROXIDATION IN HOMOGENATES OF TISSUES AS DETERMINED WITH THIOBARBITURIC ACID (TBA)*

Diet	Group No.	Addition	No. of chicks	Mean TBA units ± standard error† Liver	P	Muscle	P
A	1	None	7	373 ± 73		181 ± 12	
A	2	0·5 p.p.m. Se‡	7	135 ± 12	< 0·01	155 ± 8	0·1
A	3	100 mgm. vit. E/kgm.	4	77 ± 15		67 ± 18	
B	4	None	7	302 ± 78		171 ± 13	
B	5	0·3 per cent L-cystine	7	248 ± 49	0·6	117 ± 5	< 0·01
B	6	100 mgm. vit. E/kgm.	3	67 ± 10		38 ± 2	

* Two ml. of a 5 per cent homogenate in 0·1 *M* phosphate buffer, pH 7·4, were incubated in air in a 50 ml. stoppered flask at 37°C. with shaking in a water-bath for 1 hr. One ml. was then removed, deproteinized with 10 per cent trichloroacetic acid, and the reaction with thiobarbituric acid run on 1 ml. of supernatant.
† One TBA unit = absorbancy × 100 at 535 mμ/gm. fresh tissue.
‡ Added as sodium selenite.

With diet *A*, livers from chicks ingesting selenium (group 2) produced significantly less 'peroxides' than did the control group (1). Three of these chicks had evidence of mild exudative diathesis. The difference between the muscles from these groups was not significant.

In group 4, which had diet *B* alone, all chicks had varying degrees of muscle striation. These tissues gave thiobarbituric acid values significantly higher than those of the chicks in group 5 receiving dietary cystine (muscles without striations). With the doubly deficient muscles there was no correlation between the severity of striations and the thiobarbituric acid values. The livers from groups 4 and 5 produced amounts of 'peroxides' not significantly different.

It is important to note that these observed effects of selenium and cystine are independent of each other. Selenium shows an effect only with diet *A* which contains added cystine, and the liver but not the muscle is involved. Cystine shows its effect exclusively with diet *B* and only in the muscle. As mentioned above, dietary levels of selenium below 0·5 p.p.m. are ineffective in preventing the muscular dystrophy. It should be pointed out that diet *A* is inadequate with respect to essential fatty acids but growth is normal at this age.

Homogenates of heart and brain have been studied to a limited extent. It is of interest that although hearts from chicks fed vitamin E did not form 'peroxides' as tested above, brains from such chicks gave just as high thiobarbituric acid values as did brains from vitamin E deficient birds. This tissue also formed more 'peroxides' than any of the other tissues tested. It would appear that tocopherol does not pass the blood-brain barrier.

These studies indicate that selenium and cystine in some way alter the composition of tissues so that the capacity to peroxidize lipides is reduced. This is not a direct action since we have found that selenium and cystine when added *in vitro* to homogenates do not reduce peroxidation. Machlin *et al.*[3] have reported a similar lack of effect for selenium. It is also not probable that selenium is acting by sparing tocopherol since our experience has indicated that the rate of depletion of vitamin E from tissues is not influenced by biologically active selenium[4].

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PHYSIOLOGY

Effect of Prolonged Thyroid Administration on Aged Male Rats

THE second phase of an earlier study has been completed and it was felt that a brief note of the results would complement the first report[1]. Male Holtzman strain rats (400 gm.) were given orally purified thyroid extract ('Proloid', Warner-Chilcott) from 12 months of age until death at 21 months in three daily dosage series : *A*, *B*, and *C*, equivalent to 15, 60, and 240 mgm. respectively for a 70 kgm. human. At necropsy, all the principal organs (the same as those examined in the first phase[1]) after gross examination were fixed in buffered 10 per cent formalin, paraffin processed, and stained in the usual way and histochemically for elastic, collagenic, and reticular tissues and for neutral and acid polysaccharides, as in the first series of experiments[2-4]. Sections were compared with each other, with those of untreated control animals of equal age, and with sections obtained from rats with hypothyroidism induced by iodine-131. Organs from 84 experimental animals were studied with special regard to the vascular structures and the connective and epithelial tissues.

The examination of alterations in the cardiovascular sections (heart and all vascular levels) was interesting in that the hyper- and hypo-thyroid physiological states were not reflected histologically, with the exception of an increase of intimal acid polysaccharides in the larger vessels of the hyperthyroid animals (most marked in *B* series) and inconsistent medial fibrosis (aortic) in series *B* and *C*. Heart sections demonstrated no consistent architectural or histochemical alteration. Study of the various connective tissues indicated that other than the usual changes of age, no consistent variations from normal were present. Polysaccharide changes in ground substance were minimal between series and not consistent. Basically, it appears that under the conditions of this experiment, experimentally altered thyroid function does not affect the fundamental integrity of the connective tissues of the aged rat or alter the basic histological structure of the vascular organs.

Microscopical examination of the various epithelial structures in the series indicated that the abnormal thyroid physiological states were not reflected histologically in any consistent manner other than the expected alterations of extreme hyperthyroidism in series *C*. The only major pathological state observed was inconsistent patchy degenerative changes in the suprarenal medullary regions in series *C* animals. It would appear that in common with the vascular and connective tissues, induced hyperthyroidism under the conditions of this experiment has little effect on the overall epithelial structures in the gastro-intestinal, genito-urinary, pulmonary, and exocrine glandular organs and only the usual effects of time hyperthyroidism on the endocrine epithelial tissues in series *C*.

When these results are evaluated in combination with those of the first phase, it would appear that in spite of physiological manifestations of experimentally altered thyroid function, the basic architecture of the tissues and organs of the aged rat will not be affected, except for certain endocrine organs in extreme toxic states.

The anatomical phase of this investigation was supported by research grant *H*-1907 (*C* 3, 4), National Heart Institute, National Institutes of Health, United States Public Health Service.

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Blood Keto-acids in Kwashiorkor

DURING desalting in an electrolytic desalter (Shandon Scientific Co. Ltd., London) of urines from kwashiorkor patients, it was observed that a considerable amount of a black mercury amalgam was invariably formed. Estimation of the concentration of ammonia in these urines confirmed that the amalgam formation was due to a high ammonia content. This was in agreement with a report made earlier by Platt and Heard that ammonia excretion was increased in protein malnutrition. It was suspected at the time that this increased ammonia output may be the result of an acidification defect due to reduced hydrogen ion excretion by the renal tubules or else to the excretion of increased amounts of organic acids. Afterwards, while measuring serum transaminase-levels by the spectrophotometric method[1] it was noted that on the addition of malic or lactic dehydrogenase and reduced diphosphopyridine nucleotide to the buffered serum, the specimens from cases of kwashiorkor consumed more reduced diphosphopydrine nuleotide than normal serum. In many instances more than 30 min. were required to produce equilibrium conditions and in most cases extra reduced diphosphopyridine nucleotide would have to be added in order to produce a steady state and a high enough initial spectrophotometric reading. With normal serum on the other hand, equilibrium was usually attained in less than 10 min. and it is unusual for extra reduced diphosphopyridine nucleotide to be required. This observation pointed to the probability that ketoacids which are substrates for malic dehydrogenase and lactic dehydrogenase must accumulate in the blood in kwashiorkor.

Paper chromatography of ketoacid hydrazones according to the procedure of McArdle[2] confirmed that pyruvate mainly, and in some case α-ketoglutaric acid were present in increased concentration in the blood in kwashiorkor. Blood pyruvate was then determined by the enzyme spectrophotometric method of Segal *et al.*[3]. All the normal children and adults examined by this method had fasting blood pyruvate concentrations of 0·40–0·85 mgm./100 ml. The twenty-five kwashiorkor patients examined had fasting blood pyruvate levels ranging from 0·50 mgm./100 ml. to 2·8 mgm./100 ml.; the value was more than 1·00 mgm./100 ml. in 14 of the 25 patients. There was no correlation between blood pyruvate concentration and the clinical assessment of the severity of the case.

α-Ketoglutaric acid was determined in the perchloric acid extract used for pyruvate extimation by measuring the yellow colour of the hydrazone after pyruvate had been destroyed with lactic dehydrogenase. Normal values ranged from 0·08 to 0·22 mgm./100 ml. The kwashiorkor cases showed much variation but in only five of the twenty-five cases was α-ketoglutarate clearly above the normal range.

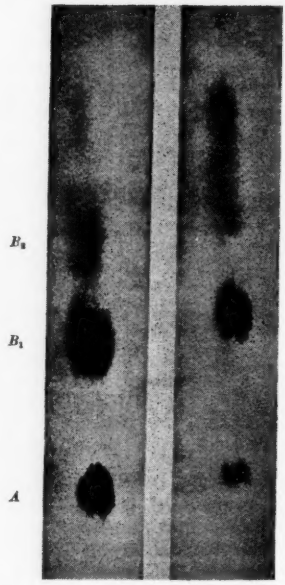

Fig. 1. (1) Chromatogram of blood ketoacids on admission. The equivalent of 0·8 ml. blood was applied. (2) Chromatogram of blood ketoacids after patient had been given the methionine supplemented, high carbohydrate diet. Same quantity of blood as in (1).
A, ketoglutaric acid spot; B_1 and B_2 pyruvate spots.

When patients are successfully treated with milk and vitamin supplements the blood pyruvate returned to normal level. When they were fed for three days with a standard diet of high carbohydrate and low protein content supplemented with 25 mgm. thiamine daily by intramuscular injection as well as other vitamins by mouth the blood pyruvate did not show any significant change. In two cases fed for three days with the same standard diet to which was added 3 gm. DL-methionine daily, the blood pyruvate showed dramatic reduction. The chromatograms of one of the cases is shown in the accompanying photographs (Fig. 1), which were taken under ultra-violet light after the papers were treated with 2 per cent. sodium hydroxide in 90 per cent ethanol. The blood pyruvate in this case was 2·6 mgm./100 ml. on admission. After three days on the diet supplement with methionine, the value had fallen to 1·2 mgm./100 ml. There is thus evidence that the accumulation of pyruvate may be due, at least in part, to deficiency of sulphydryl groups. The matter is being further investigated in this laboratory.

I am indebted to Dr. W. R. F. Collis, head of the Department of Child Health in the College, for clinical facilities to carry out this investigation.

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Effect of Acetylcholine and Eserine on the Spawning of *Hydractinia echinata*

It is usually considered that the responses of coelenterates are not mediated by acetylcholine[1], because: (1) there is no evidence of significant amounts of acetylcholine or choline esterase in their bodies; (2) neither these substances, nor atropine, nor curare, affects their neuromuscular activities[2]. However, I have recently found that acetylcholine (Roche) and physostigmine (eserine; B.D.H.) affect the spawning activity of *Hydractinia echinata*.

As previously reported[3,4], spawning is induced by a suitable periodicity of lighting, darkness conditioning the response which is triggered by light. When isolated gonophores are subjected to sea water containing either acetylcholine (concentration; 5×10^{-4}) or eserine (concentration; 10^{-4}) during the periods of darkness, discharge is inhibited in 50–80 per cent of the mature gonophores; but a number of treated gonophores, both male and female, spawn in the dark without light treatment. Concentrations of both substances above 10^{-3} inhibit spawning completely and those below 10^{-5} are ineffective.

As neither of the drugs acts when introduced at the beginning of illumination, or even 5 min. before the illumination is due to start, it is clear that the triggering process is insensitive to them.

Thus, they appear to act in two ways; in one, by interfering with the increase in photosensitivity during darkness, and in the other, by triggering off the final process of spawning. It is also worth noting that sensitivity to either acetylcholine or eserine coincides in time with sensitivity to calcium[4].

Whether a true cholinergic mechanism exists, and how it is related to calcium, remains to be discovered.

The work was done whilst holding a research fellowship of Bedford College and I am greatly indebted to Dr. C. H. Mortimer and the members of the staff of the Millport Marine Station for providing facilities.

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Transmission of Passive Immunity in an Insectivore

The hypothesis[1] that antibodies are not transmitted through placentæ of the epitheliochorial and syndesmochorial types and are transmitted through hæmochorial and hæmoendothelial types was at one time widely accepted. More recently it has been demonstrated in the rabbit[2] and guinea pig[3] in which the placentæ are hæmochorial that the transmission of antibodies occurs exclusively via the yolk sac. In the rat transmission occurs by way of the yolk-sac endoderm and by way of the gut, and in this species some transmission across the hæmochorial placenta could not be excluded[4].

In the hedgehog the placenta is hæmochorial and in the young of animals immunized against *Brucella abortus*, specific agglutinins could not be detected in the sera before suckling. The females received immunizing injections before and during pregnancy, and the maternal antibody titres during pregnancy were of the order 1/640 to 1/1280. The sera of 10 young derived from 6 litters, which were removed from their mothers before suckling occurred gave negative results at dilutions of 1/10. In this species the yolk sac persists to term and its abembryonic wall remains intact[5], whereas in the rabbit, guinea pig and rat the yolk sac is of the inverted type in which the abembryonic bilaminar segment is broken down and the yolk-sac splanchnopleur is exposed to the uterine lumen.

The young of ruminants, horse and pig are born without antibodies, and in these species a rapid uptake of antibody occurs from the colostrum and milk during a 36-hr. period after birth. During this period the antibody titre of the serum of the young animal increases to become approximately equivalent to that of the maternal serum. The antibody of the colostrum in these animals attains titres which equal or exceed those of the maternal serum. In the hedgehog the antibody titre of the first milk closely approximates the maternal serum titre; but with suckling the titre declines so that in the nursing female six days after parturition it is about 25 per cent of the maternal serum titre. In this species there is an uptake of antibody from the milk by the gut; but even after several days the titre attained in the serum of the young hedgehog is only a small fraction of that in the maternal serum. The highest serum titre so far obtained in a young animal is 1/20, with partial agglutination at 1/40, at 6½ days of age, the titres of the maternal serum and milk being 1/640 and 1/160 respectively. In this representative of a primitive mammalian order transfer of anti-*Brucella* agglutinins does not occur prenatally, and the postnatal transmission is of a very low order when compared with other species in which the young obtain passive immunity after birth.

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Release of Histamine from Rat Mast Cells by Blood Treated with Dextran

Halpern[1] has shown that the injection of dextran into albino rats causes increased capillary permeability and shock. Coincident with the appearance of shock, there is a massive release of histamine into the blood stream of injected animals. The liberated histamine probably accounts for the greater part of the increased capillary permeability and shock resulting from the administration of dextran. It seemed of interest, therefore, to investigate the mechanism of the release of histamine. It was found that dextran reacts with a plasma protein to produce a substance which acts on mast cells to release histamine.

Peritoneal cavity cells, including mast cells, were obtained from the rat by a method previously described[2]. To detect mast cell disruption, one drop of the cell suspension was added to one drop of rat serum or serum fraction at room temperature, and the preparations were examined under the microscope. Histamine assays were performed by the method of Lowry *et al.*[3]

Satisfactory results were obtained only when the solutions had a *p*H of less than 7·5. For this reason blood was collected and centrifuged under paraffin.

A substance causing disruption of mast cells and release of histamine was present in the sera of rats 60 min. after intraperitoneal injection and 30 min. after intravenous injection of dextran ('Dextraven' in physiological saline, 30 mgm. dextran/100 gm. body-weight). Greater concentrations of this active principle appeared more rapidly in the sera of adrenalectomized rats after injections of similar amounts of dextran. Death occurred within 30 min. in these animals. Intraperitoneal injections of hydrocortisone sodium succinate ('Solu Cortef', Upjohn, 200 mgm./kgm.) given daily for 5 days prior to challenge with dextran prevented death of the adrenalectomized animals. The sera of these animals was comparable in its activity on mast cells with sera from dextran-injected normal rats.

The active principle was also produced *in vitro* when dextran was added to serum from normal rats, adrenalectomized rats and hydrocortisone-treated adrenalectomized rats. Its concentration was greater when the serum was obtained from adrenalectomized rats than when obtained from normal and hydrocortisone-treated adrenalectomized rats. The histamine-releasing substance was produced rapidly at room temperature when the *p*H of the serum-dextran mixture was between 7·0 and 7·5 but did not appear when dextrose (2 mgm./ml.) was added to the dextran solution before this was placed in contact with the serum. The addition of hydrocortisone *in vitro* did not affect the concentration of the active principle. Again, its production was not inhibited by inactivation of serum complement (60°C. for 5 min.) or by iodoacetate, phenylmercuric acetate, sodium fluoride or soya bean trypsin inhibitor (Nutritional Biochemicals).

A β- and γ-globulin fraction of rat serum prepared by precipitation with 25 per cent ethanol at −5°C. did not disrupt mast cells when dissolved at *p*H 7·0. Addition of dextran to the fraction produced an active histamine-release substance but the presence of dextrose inhibited the interaction. Similar results were obtained when another polysaccharide (zymosan, Nutritional Biochemicals; 5 mgm./ml. serum) was added to rat serum *in vitro* and to the β- and γ-globulin preparation.

In earlier work it was shown that a polypeptide from nucleated cells acts on mast cells *in vitro* and causes them to disrupt with the release of histamine[2,4]. The substance responsible for disrupting the mast cells is probably a histone or histone-breakdown product. The mechanism suggested by the present work involves the release of an active substance from rat serum or a serum fraction. The active principle is produced in the serum of rats following injections of a polysaccharide (dextran). It is also found in rat serum in the absence of cells, when dextran or another polysaccharide (zymosan) is added to the serum *in vitro*.

While it may be tempting to suggest that an antigen-antibody reaction is involved (dextran versus a normal antibody to dextran in rat serum), there is no proof that this is the mechanism.

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PATHOLOGY

Transformations of Myxoma into Vaccinia or Ectromelia Virus in Tissue Culture

The Berry–Dedrick transformation[1] is known as the first instance of what is called genetic interaction between animal viruses, but the investigation of this phenomenon has been restricted to a combination of active fibroma and heat-killed myxoma, except for some studies on recombination of the influenza group[2,3]. In a previous paper[4], a new example of viral transformation was demonstrated using active ectromelia and heat-inactivated vaccinia. The present investigation was undertaken to see if the same phenomena could occur between the other viruses classified in the pox group.

The *IHD* strain of vaccinia or the Biken strain of ectromelia was heat-inactivated and myxoma was used as live virus (Table 1.)

Table 1. Comparison of Characteristics of Viruses Used

Virus	Pathogenicity		Viral growth in tissue culture	
	Rabbit*	Mice†	*FL*‡	*L*§
Myxoma	Skin tumour lethal	No	+	−
Vaccinia	Skin lesion not lethal	No	+	+
Electromelia	No	Lethal	+	+

* Intradermal injection.

† Intraperitoneal injection.

‡ Growth medium: 0·5 per cent lactalbumin hydrolysate in Earle's balanced salt solution with 15 per cent bovine serum.

§ Growth medium: 0·5 per cent lactalbumin hydrolysate and 0·1 per cent yeast extract in Hanks's balanced salt solution with 5 per cent bovine serum.

Myxoma virus obtained from skin tumours of domestic rabbits was passaged twice in the human amnion cell (*FL* strain), where the virus could be propagated forming cytoplasmic inclusion bodies. 7 days after inoculation the titre of intracellular virus reached about 10^6 *ID* (in rabbit)[5,6].

Vaccinia and ectromelia were used after serial passage in *L* cells. The infected monolayers were freeze-thawed in the presence of growth medium and centrifuged at 3,000 r.p.m. for 5 min. The supernatant fluids from this centrifugation, which contained on the average about 10^6 *TCID*50/ml. of virus, were heated at 56° C. for two hours (vaccinia) or one hour (ectromelia). At this temperature, vaccinia can be inactivated to a survival of less than 10^{-6} within 30 min., while ectromelia can be inactivated within 15 min. No active virus was found in tissue culture or in the respective host animal inoculated with these heated preparations.

The transformations were carried out in *FL* cells grown in 200 ml. prescription bottles. Cellular monolayers (about 5×10^6 cell/bottle) were exposed to a mixture of 1 ml. of infectious myxoma (10^5–10^6 *ID* in rabbit) and 1 ml. of heat-inactivated virus preparation of vaccinia or extromelia which had been added to 8 ml. of growth medium. Culture medium was changed twice weekly with fresh medium containing 1 ml. of heat-inactivated virus preparations. 7 days after inoculation, infected cells were disrupted by freeze-thawing, and centrifuged 3,000 r.p.m. for 5 min. One ml. of the supernatant was transferred into monolayers of *L* cells.

The cytopathic change similar to those of vaccinia or ectromelia was shown after 2 or 3 days. This would indicate that the transformation of myxoma into

vaccinia or ectromelia had taken place. The transformed virus was purified twice by limiting dilution passages. The purified viruses had the same pathogenicity for rabbits and mice as each original virus strain.

Preliminary work using fibroma virus showed that fibroma also could be transformed into vaccinia by the similar procedure.

With heat-killed vaccinia, poliomyelitis (Type 1, Brunhilde strain) and measles (Edmonston strain) could not lead to transformation when used as active virus. Recently it was shown in our laboratory that myxoma was closely related serologically to vaccinia and ectromelia[7]. These results may suggest that there is a correlation between transformation and cross-immunity.

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Protein Synthesis in Macrophages containing *Eimeria tenella*

RECENT studies on bacteriophage have shown that the virus may stimulate anabolic protein metabolism in the parasitized bacterial cell and, furthermore, deflect metabolic processes towards the production of bacteriophage nucleoprotein.

This is a preliminary report of a similar phenomenon in intestinal macrophages of the chick which have become invaded by the sporozoan *Eimeria tenella*. Briefly, the process of infection consists of swallowing the oocyst which breaks down in the small intestine, liberating sporozoites. These invade the cells in the cæcal wall and undergo schizogony within the cells, liberating merozoites which re-invade the gut wall.

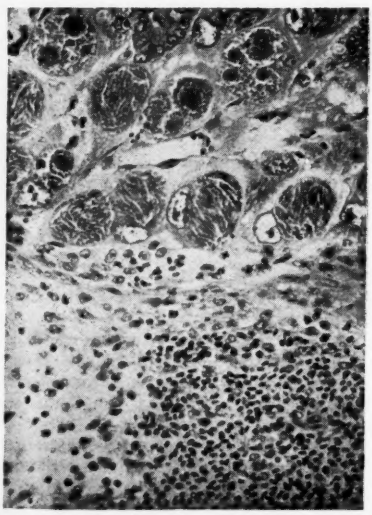

Fig. 1. T.S. of chick cæcal wall seven days after oral *E. tenella*. Parasites in macrophages (upper part of picture). Hæmorrhagic exudate in submucosa (lower part of picture). (H and E. × 440)

This process was studied by standard histological methods and by histochemical methods in the cæca taken from a chick seven days after oral infection. The parasite can be seen in large macrophages which often entirely replace the lamina propria mucosæ; adjacent to this there is a conspicuous exudate composed mainly of red cells with a moderate number of eosinophil leucocytes. The adjacent epithelial cells of the gut show numerous mitotic figures and many contain globules of secretion.

The parasitized macrophages are considerably enlarged (Fig. 1) and filled with protein, most of which appears to be ribonucleic acid as judged by the 'tetrazo' method and by pyronin staining using ribonuclease as a control measure. In the early stages the ribonucleoprotein collects at the centre of the cell surrounded by a palisade of developing schizonts. Later the cell fills with schizonts and the ribonucleoprotein is presumably incorporated within them.

The nuclei of the macrophages are greatly enlarged, displaced to the side of the cell and show two or three big nucleoli. This is an index of intense protein synthetic activity by the cell. The fate of the macrophages is, at present, uncertain since it is unusual to find evidence of damage to these cells. They may liberate the merozoites and serve as a breeding ground for even more.

The histological appearances suggest an enhanced ribonucleoprotein production within chick macrophages parasitized by *Eimeria tenella*, and furthermore that this new protein is incorporated into the newly formed merozoites.

Further confirmation of this view will be attempted by the use of fluorescent conjugates of chick and *Eimeria* protein and the results will be reported in due course.

We are grateful to Dr. J. Beattie and Dr. L. Horton-Smith for the opportunity to study this material.

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HISTOLOGY

Histochemical Use of the Cyanocarbon Organic Compounds

MEMBERS of the new group of organic compounds called 'cyanocarbons'[1] appear worthy of investigation as histochemical localization reagents on the basis of preliminary studies made with one of the series, tetracyanoethylene. These compounds are chemically quite active and will take part in a large number of organic reactions.[1-4] For example, tetracyanoethylene may, in proper circumstances, react through additions to its double bonding with such radicals as dienes, ketones and hydrogen, and through replacement of cyano groups, it will react with the alkoxy, hydroxy, and aminoaryl radicals. The products of many such reactions are coloured. Tetracyanoethylene produces an intense yellow colour with benzene, orange with toluene, and red with xylene. Reactions with certain amines will produce 4-tricyanovinylamines, a class of brilliant orange to blue dyes.

Experiments utilizing animal and human necropsy tissues, 10 per cent buffered formalin and Bouin's

fluid fixed and paraffin processed, suggest that tetracyanoethylene may well be an interesting protein localization reagent. In general, fairly good colorations are found at tissue sites usually associated with such complexes. This does not, however, preclude its use in the localization of other tissue components. The solvent problem is a serious one with tetracyanoethylene since it will react with most organic solvents. Best results have been obtained with 0·5–2 per cent solutions in tetrahydrofuran, ethyl acetate dimethylsulphoxide, or dimethylformamide[5]. Only the finest grades of these solvents should be used since impurities will introduce complicating side-reactions. Staining times vary and depend upon the strength of the staining solution but sections treated 2 hr. in a 0·5 per cent solution at room temperature show adequate coloration regardless of solvent used. Care must be taken during staining to avoid contamination of the solutions because of the active chemical nature of tetracyanoethylene. The dehydration process after staining should be done without unnecessary delay. The localizations are usually yellow, suggesting the benzene ring, and at times are transient. Especially strong colorations are frequently obtained at the sites of iron pigments. It is important to remember that certain of the solvents may be quite toxic, and special care to avoid their fumes is necessary during the staining procedure. The use of a hood is recommended. Detailed experiments on the histochemical value of this series of compounds are now in progress. Unfortunately, cyanocarbon chemicals are still in the experimental stage and are not readily available commercially. However, in the near future they probably will be placed on the market and may be easily obtained by interested persons.

I would like to express my appreciation to Dupont de Nemours and Co. for providing the tetracyanoethylene used in these experiments, to Dr. B. C. McKusick and Dr. T. C. Cairns for their helpful comments on the nature of tetracyanoethylene, and to note that this investigation was supported by research grant *H*-1907 (*C* 3, 4), National Heart Institute, National Institutes of Health, United States Public Health Service.

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Mast Cell Population of Lung of the Guinea Pig and other Tissues

In 1941 Jacques and Waters mentioned the degranulation of mast cells in the liver of a dog undergoing anaphylactic shock[1]. In 1952 Stuart stated that the shock organs of anaphylaxis in the dog, rabbit, and guinea pig all contain mast cells which degranulate when a sensitized animal is injected with antigen[2]. Unfortunately, no details were given of the histological techniques he used. More recently, Mota and Vugman have reported some experiments from which it was concluded that anaphylaxis in the lung of the guinea pig caused a marked reduction in the number of mast cells histologically demonstrable in that organ[3].

In this laboratory an attempt to demonstrate mast cell degranulation in guinea pig lung following antigen administration to a sensitized animal led to a series of surprising observations. All the tissues used in these investigations were fixed for 24 hr. in absolute ethyl alcohol. Pieces of lung, liver and skin were embedded in paraffin and examined as sections 10 μ thick. Spreads of connective tissue or pleura were examined directly. In all, four different stains were used to demonstrate mast cells in the tissues. These were: (1) thionin as a saturated solution in 50 per cent alcohol; (2) toluidine blue as an 0·5 per cent solution in 50 per cent alcohol; (3) polychrome methylene blue as an aqueous solution; (4) acetylated sudan black as a saturated solution in 70 per cent alcohol. The first three stain metachromatically the heparin in the mast cell granules and the last-named stains the phospholipid in the mast cell granules.

Using these stains, mast cells were readily discernible in most of the tissues examined. Abundant mast cells were found in the mesentery of the hamster, and a slightly smaller number in the cheek pouch of that animal. Spreads of mouse mesentery were found to contain a slightly smaller number of mast cells than hamster cheek pouch, and so also were sections of the abdominal skin of the rat. A similar number of mast cells were observed in omentum, mesentery and pleura of the guinea pig. In the parenchyma of the lung around the major blood vessels and air passages no mast cells were visible in sections taken from either normal or sensitized unshocked guinea pigs. They were also absent in sections of guinea pig skin. It was thus not possible to demonstrate mast cell degranulation in lung tissue of sensitized guinea pigs after intravenous challenge with antigen. Whereas mast cells in the omentum or mesentery of the guinea pig showed no change after anaphylactic shock, a large number of the mast cells seen in guinea pig pleura were disrupted or degranulated after antigen challenge. Mast cells were observed in normal dog liver. They were slightly less numerous and not quite so well differentiated as in other tissues. Only about half the normal number were visible in sections taken from dog liver 1 hr. after intravenous challenge under pentobarbitone anæsthesia with a shock dose of antigen causing an immediate fall in blood pressure from 130 to 10 mm. mercury. No mast cells could be demonstrated in rabbit lung adjacent to the point of entry of the pulmonary artery.

These observations invite one or two obvious conclusions. Mast cells in the liver of the dog undergo degranulation and disruption during anaphylactic shock thus confirming the observation of Jacques and Waters. The same is not true of the lung of the guinea pig or rabbit, since, contrary to Stuart's suggestions, in these experiments mast cells appeared to be absent from the respective shock organs. It thus seems not unlikely that the histamine which causes rapid onset of fatal bronchoconstriction in the guinea pig during anaphylaxis is derived from some structure other than the connective tissue mast cell. Anaphylactic histamine in the rabbit is also most probably not of mast cell origin.

It is possibly relevant that Mota and Vugman, who reported high mast cell counts in the lung of the guinea pig, used as a fixative a 4 per cent solution of lead subacetate in 50 per cent ethanol containing 0·5 per cent acetic acid. They then prepared frozen sections of the lung 50μ thick which were stained with toluidine blue. Gomori condemns the use of lead in frozen sections and states that whereas lead adsorbed in paraffin sections can be readily washed out by dilute acetic acid, frozen sections may hold lead so stubbornly that even prolonged washing in strong acetic acid cannot remove it completely[4]. It is surprising therefore, to be confronted with evidence implying that mast cells in the lung of the guinea pig can only be detected after prior treatment of the tissue with lead even though they can be readily observed elsewhere without such prior treatment, but worth noting, however, that Bloom has reported that metrial gland cells of the rat uterus show definite metachromasia after fixation in lead acetate, a very faint metachromasia after fixing in methanol and no metachromasia at all after fixation in other fixatives (Bloom, personal communication). Alternatively, Mota and Vugman succeeded in staining with toluidine blue lead which had been adsorbed on to some morphological structure which was not a connective tissue mast cell.

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RADIOBIOLOGY

Effect of the Level of Microbial Population on Isotopically Exchangeable Phosphate in Soil

If a soil is shaken with a phosphate solution labelled with phosphorus-32 the specific activity (phosphorus-32/phosphorus-31) is reduced in consequence of isotopic exchange with the 'exchangeable' phosphate in the soil. At equilibrium the following relationship holds: phosphorus-32/phosphorus-31 in the solution = phosphorus-32/phosphorus-31 in the exchangeable form in the soil. The specific activity in solution can be determined by assay while the phosphorus-32 in the soil can be calculated by the difference between the initial and final phosphorus-32 contents of the solution. The amount of phosphate in the soil which has exchanged isotopically under the conditions of the experiment can readily be calculated[1-4]. It is also possible to calculate the quantity of phosphate which is removed or 'sorbed' by the soil from the change in concentration of inactive phosphate in the solution. The amount of phosphate which plants will absorb does not always bear a simple relationship to these quantities; but knowledge of 'exchangeable' or 'sorbed' phosphate in the soil can be of value in the study of factors which control the availability of phosphate to plants.

It has been assumed by previous investigators that the value of isotopically exchangeable phosphate would be unaffected by the level of microbial population in the system during the period of equilibration. Until recently the evaluation of the effects of micro-organisms has been difficult to make since conventional methods for destroying micro-organisms in soil, for example, by means of steam or chemicals, may well modify surfaces on which the exchange of phosphate occurs. The γ-rays from cobalt-60 now, however, provide a convenient physical method for reducing the level of microbial population without causing an appreciable rise in temperature of the soil during the period of irradiation. Accordingly, the determination of isotopically exchangeable phosphate by the method of Russell *et al.*[1] has been investigated both in the normal air-dry soil and in soil previously irradiated with γ-rays from cobalt-60.

Samples of the selected soil, a Middle Lias loam from Banbury, Oxfordshire (pH 7·6), were sealed into glass ampoules which were themselves sealed into separate polythene envelopes. After irradiation with 10^6 reps of γ-rays from cobalt-60, the ampoules were removed from the polythene envelopes under aseptic conditions and put into tubes containing labelled phosphate solutions which had been sterilized in an autoclave at 1·5 atmospheres for 20 min. Sterile rubber bungs with glass rods projecting from their lower surfaces were inserted into the tubes and the ampoules were broken by shaking them sharply against the rods. The irradiated soil was thus introduced into a sterile solution with the minimum risk of microbial contamination. Control samples which had not been irradiated were transferred in the same way.

Microbiological assay and measurements of 'exchangeable' and 'sorbed' phosphate were made after different intervals of time in two experiments (Table 1). Using a dilution plate method the microbiological population was shown to consist almost entirely of bacteria; very few fungi were detected (<1 colony per plate at the highest concentration). For the purposes of the present investigation, therefore, the bacterial plate count has been taken as an index of microbial activity, and while the shortcomings of this method were appreciated, it was considered an adequate indication of the relative abundance of viable micro-organisms. Complete sterility was not achieved by irradiation but a reduction of the bacterial population by a factor greater than 1,000 was achieved in tubes examined after one day. The population thereafter increased due apparently to the multiplication of bacteria which survived irradiation, but in all cases the bacterial population was very small by comparison with that in the tubes which had not been irradiated. Irradiation had no statistically significant effect on the values for 'exchangeable' or 'sorbed' phosphate, although there was a tendency for the latter value to be decreased.

These experiments give clear evidence that bacteria and probably other micro-organisms present during

Table 1. Effect of irradiation with γ-rays on 'exchangeable' and 'sorbed' phosphate and bacterial population after different periods of shaking

(Values for 'exchangeable' and 'sorbed' phosphate in mgm. P/5 gm. soil)

	Duration of shaking (days)	Irradiated	Control	S.D. ($P=0·05$)
Exp. 1				
'Exchangeable' phosphate	1	0·63	0·63	0·17
	7	1·10	1·20	
'Sorbed' phosphate	1	1·65	1·69	0·07
	7	2·19	2·26	
Bacterial population (per gm. soil)	1	$5·4\times10^3$	$1·7\times10^7$	
	7	$4·6\times10^4$	$1·1\times10^8$	
Exp. 2				
'Exchangeable' phosphate	7	1·07	0·98	0·12
	14	1·00	1·02	
'Sorbed' phosphate	7	2·34	2·36	0·07
	14	2·57	2·64	
Bacterial population (per gm. soil)	7	$<1\times10^5$	$2·5\times10^7$	
	14	$<9\times10^5$	$6·9\times10^7$	

the period of equilibration cannot account for any large fraction of isotopically exchangeable phosphate in this soil as determined by this method.

We are indebted to Dr. R. Scott Russell for much useful discussion and to Mr. W. Hutchinson of the Technological Irradiation Group of the Isotope Division, Atomic Energy Research Establishment, for carrying out the irradiation of the samples.

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Pharmacological Suppression of Increased Capillary Permeability following Irradiation of the Intestine of Rats

The syndrome of acute intestinal lesions due to ionizing radiation leading to an early death of the animals has been described by many workers[1–5]. The present work is concerned with the increase of the capillary permeability in the intestinal tract of rats after irradiation and the suppression of this phenomenon by the action of drugs affecting the esterase systems.

The increased capillary permeability following turpentine-induced pleurisy[6,7] and thermal burns in rats[8,9] can be inhibited by pretreating the animals with antihistamines and anti-esterase drugs.

The increased permeability due to irradiation was investigated in male rats weighing 200–250 gm., which were exposed, under nembutal anæsthesia to a dose of 1,500r. of 200 kV. X-rays given in 11 min. over a circular abdominal field of 1·5 in. diameter. At intervals of 1–4 days after exposure a solution of trypan blue was injected into the tail vein and the animal killed 30 min. later[6]. In the irradiated animals the dye left the capillaries and stained the intestine blue. This phenomenon began after 24 hr. and reached its maximum after 3 days. The staining in different regions varied in intensity and in order to evaluate it the affected length was expressed as a percentage of the total length of the intestine.

Animals irradiated with no pretreatment showed a progressive increase in the intensity and length of the intestine that was stained; at 24 hr. 37·7 per cent, 48 hr. 73·4 per cent and 72 hr. 92·0 per cent of the gut was affected.

Pretreatment of the animals immediately before irradiation with a single intramuscular injection of di-*iso*propylfluorophosphate, 3 mgm./kgm. body weight in arachis oil, suppressed the staining of the intestine completely after 24 hr. and at 48 hr. reduced the length stained to only 20 per cent of the whole. Similar results were obtained with (*a*) quinine dihydrochloride (125 mgm./kgm. injected immediately before irradiation, a further dose of 40 mgm./kgm. given at 24 hr. and 5 mgm./ml. added to the drinking water); (*b*) quinidine sulphate (250 mgm./kgm. in propylene glycol given before irradiation plus 150 mgm./kgm. at 24 hr. after irradiation); (*c*) chloroquine sulphate 'Nivaquine', (40 mgm./kgm., before radiation plus 25 mgm./kgm. at 24 hours).

Pretreatment with mepyramine maleate, 'Anthisan' (1 mgm./kgm. and subsequently administered in the drinking water 1 mgm./ml.), reduced the length of the intestine stained to 10 per cent of the total length of 24 hr., but had no observable effect after 48 hr. despite repeated administration of this drug. Pretreatment with 2-bromo-*d*-lysergic acid (*BOL* 148) had a slight effect on the length of the intestine stained at 24 hr. following radiation but no effect at 48 hr.

The results, which will be published in detail elsewhere, are strikingly similar to those obtained with similar pretreatments to thermal burns. Since the effective drugs inhibit pseudo-cholinesterase, their action may be due to suppression of an esterase system.

I wish to thank Dr. H. B. Fell and Dr. A. Glucksmann for their advice and encouragement, and Messrs. Sandoz for the gift of *BOL* 148.

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Decrease in Radiosensitivity of the Intact Mouse Spleen produced by Hypoxia

The radio-protective effects of low oxygen tensions in tissues during exposure to X-rays has been described by Gray and his associates[1]. Wright and Howard-Flanders[2] have demonstrated the protective action of severe hypoxia on the irradiated mouse-tail, and Wright[3] has observed increased resistance of the intact mouse thymus, irradiated while the animal was breathing nitrogen.

An attempt has been made to determine the effects of severe hypoxia on the intact spleen of irradiated mice. 60–70-day old *T.O.* strain male mice, weighing 22–24 gm. were anæsthetized with an intraperitoneal injection of 7·5 mgm. 'Avertin' (tribromoethanol) in a volume of 0·3 ml. In one group of animals at laparotomy a soft catgut noose threaded through a polyethylene sleeve was placed around the splenic pedicle, drawn tight and held with a bulldog clip. The spleen was then returned to the peritoneal cavity which was closed with sutures. After 10 minutes at room temperature, by which time the spleen was almost black, the animals were exposed to 800 r. whole-body irradiation. The ligatures were then removed and the wound sutured. Another group of animals had their splenic pedicles ligated after irradiation. A third group of mice was irradiated after laparotomy alone, and a fourth untreated group acted as control.

All mice were killed by cervical dislocation 5 days after treatment. Their spleens were removed and fixed overnight in Bouin's fluid, weighed after blotting dry and later examined histologically. The assessment by weight of irradiation damage to the spleen has been described by Carter, Harris and Brennan[4]. The splenic weights are shown in Table 1, together with their standard deviations and the numbers of animals used in brackets.

Table 1. Mean weights of fixed spleens (mgm.) with their standard deviations, five days after irradiation

Untreated controls	Irradiation only	Spleen ligated then irradiated	Irradiation then ligation
63 ± 8 (12)	24 ± 8 (8)	70 ± 14 (8)	22 ± 7 (7)

As vascular disturbances followed ligation of the splenic pedicle, direct comparison of splenic weights was only considered profitable between the two ligated groups. A t-test shows that the spleens of animals ligated and then irradiated weigh significantly more than those irradiated and then ligated ($t=7{\cdot}2$ with 13 degrees of freedom ; $P<0{\cdot}001$).

Histological examination of the spleens confirms that the heavier group of spleens are less damaged than the lighter group. In the animals which had the ligature applied after irradiation, no primary lymphatic nodules are present. Groups of small and a few medium size lymphocytes are observed in narrow perivascular cuffs. No lymphoblasts and very few megakaryocytes can be seen. This group closely resembles the group irradiated after the sham operation.

In the spleens of mice irradiated while the ligatures were in place, the normal follicular architecture has disappeared. However, groups of lymphoblasts, large and small lymphocytes, megakaryocytes, myeloblasts and polymorphonuclear leucocytes are seen and mitotic figures are present. Vascular engorgement is an outstanding feature of this group in comparison with the previous one, and must account for some of the difference in weight between them.

My thanks are due to Dr. L. H. Gray for suggesting these experiments and to Dr. J. S. F. Niven for her advice.

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PALÆONTOLOGY

Conchiolin Remnants in Mother-of-Pearl from Fossil Cephalopoda

Decalcification of mother-of-pearl from recent molluscs leaves soft, stratified membranes of conchiolin. These membranes, cleaved and broken by ultrasonic vibrations, appear in the electron microscope as fragments of lace-like reticulated sheets or perforated leaflets[1]. The pattern of these structures differs with the groups and species of molluscs. Three main patterns (nautiloid, gastropod and pelecypod) have been provisionally recognized[1]. Replicas of surfaces of mother-of-pearl, prepared before and after corrosion by decalcifiers, have shown that the reticulated sheets correspond to the conchiolin membranes which alternate with the mineral lamellæ in the stratified nacreous configuration, and which separate the individual crystals of aragonite disposed side by side in each lamella[2].

The three patterns of structure of conchiolin have been also detected in mother-of-pearl from Holocene to Jurassic molluscs[3].

The latter investigations have been extended to 40 specimens from 18 genera of Eocene, Cretaceous, Jurassic, Pennsylvanian and Ordovician Cephalopoda (Ammonoidea and Nautiloidea). In preliminary observations, reticulated sheets, exhibiting the nautiloid pattern altered in different ways, were found in mother-of-pearl from 3 specimens of *Eutrephoceras* (including *E. dekayi*), *Placenticeras* (Cretaceous), *Leioceras opalinum* Reinecke (Jurassic), *Eoasianites* (?) sp., *Pseudorthoceras knoxense*, an undetermined nautiloid (Pennsylvanian), *Dolorthoceras sociale* (Ordovician).

Fig. 1 shows in decalcified mother-of-pearl from *Nautilus macromphalus* Sowerby (Recent) a reticulated sheet consisting of sturdy trabeculæ, separating elongated or rounded openings of irregular outlines. Fig. 2 represents a reticulated sheet from an unidentified Pennsylvanian nautiloid collected in the asphaltic formations near Sulphur (Oklahoma), a locality in which the original mineralogical structure of aragonite has been preserved unaltered[4]. Comparison between Fig. 2 and Fig. 1, gives evidence of a great similarity of structure between Recent and Pennsylvanian nacreous conchiolin membranes. In some areas of the fossil material, the fabrics appear shrunk or flattened. However, these modifications were also observed in the sheets of the recent *Nautilus*.

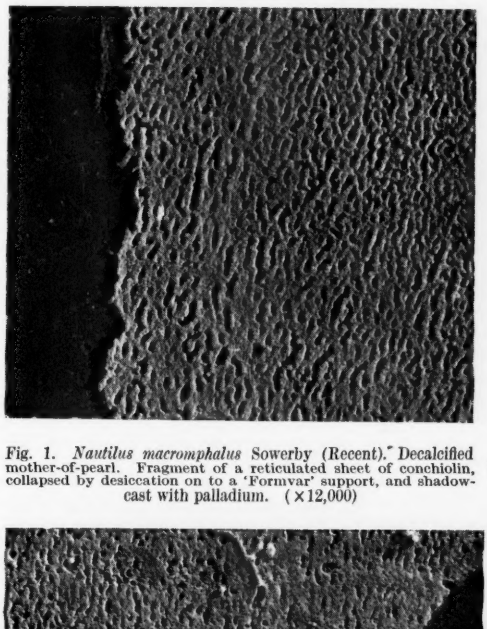

Fig. 1. *Nautilus macromphalus* Sowerby (Recent). Decalcified mother-of-pearl. Fragment of a reticulated sheet of conchiolin, collapsed by desiccation on to a 'Formvar' support, and shadow-cast with palladium. (×12,000)

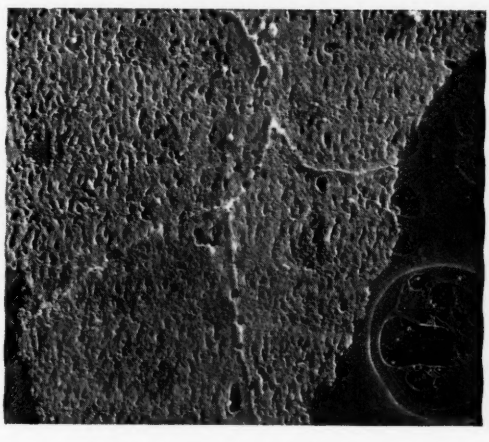

Fig. 2. Unidentified nautiloid (Pennsylvanian). Decalcified mother-of-pearl. Fragment of an interlamellar reticulated sheet lying on a perforated membrane of 'Formvar', and shadow-cast with palladium. The areas corresponding to the edges of crystals of aragonite of a lamella, originally superimposed on the organic sheet and dissolved by the decalcifier, appear as white ridges, erected upwards above the sheet. (×12,000)

The results so far obtained indicate a great stability of the conchiolin patterns throughout considerable periods of time, in favourable burial conditions, as in Sulphur (more than 200 millions of years in the Pennsylvanian specimens). The results suggest also that recordings of the micro-architecture of conchiolin remains might give useful information about the identity of fossil shells, in which the fragments of the test available are too small or too dissociated to be studied by the classical methods of palæontology.

I am grateful to Prof. Tove Birkelund, Dr. G. Arthur Cooper, Prof. William M. Furnish, Dr. P. L. Maubeuge, Prof. Norman D. Newell, Prof. A. Rosenkrantz and to Prof. Dr. O. H. Schindewolf for gifts of generous collections of finely preserved mother-of-pearl of Cephalopoda.

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BIOLOGY

Discarded Blood Bank Blood as a Source of Protein for Cultivation of HeLa Cells

Most mammalian cell cultures require serum protein for continued survival and growth. Serum protein is probably the most expensive component of tissue and cell culture media, especially if human cells are cultivated in homologous serum. We have studied the possibility of employing outdated blood bank blood as a possible source of the protein necessary for the growth of HeLa cells. Such discarded blood is available in fairly large quantities and if it could be successfully employed for cell cultures an expensive bleeding programme could be dispensed with.

In order to ascertain whether the fluid portion of such blood would support the growth of HeLa cells it was necessary to free the plasma of the citrate ion used as an anticoagulant. Plasma was removed from the blood and placed in large 'Cellophane' dialysing tubes, 80 mm. flat diameter. Plasma was dialysed against 6 to 7 volumes of demineralized water. The dialysing water was changed 6 times at 6–12 hour intervals. Finally, the plasma was dialysed against Hanks's balanced salt solution overnight which replenished the calcium and magnesium ions and permitted the plasma to clot. Serum protein was removed and sterilized by filtration through 'Selas' unglazed porcelain candles, 02 porosity. Such dialysed preparations obtained from blood bank blood were tested for their ability to support growth of HeLa cells and were compared with medium containing serum from fresh undialysed blood and also with Eagle's medium[1]. Since dialysable components of serum are necessary for the growth of HeLa cells, the dialysed serum was supplemented with yeast extract which has been shown to have a serum-sparing effect[2]. Yeast extract contains many amino-acids and vitamins, is economical, and can be autoclaved and retain its serum-sparing effect.

For the tests, aliquots containing 60,000 trypsinized HeLa cells each were dispensed into 100 screw-capped test-tubes, 16 × 125 mm. The medium employed for dispensation was 30 per cent processed blood bank serum protein supplemented with 0·2 per cent yeast extract in Hanks's balanced salt solution. On the following day, medium was decanted and cells washed 3 times with balanced salt solution and the indicated media added. Tubes were placed in the roller drum and replicate tubes removed and counted at the times indicated. Each count represents the average of three tubes. Media was replaced every 48–72 hours. The results, represented in Table 1, indicate that such processed serum protein, when supplemented with yeast extract, compares favourably with whole serum in the ability to support the growth of HeLa cells. It is also interesting to note that the dialysed components of serum can be replaced by yeast extract. The failure of Eagle's medium to support growth of HeLa cells when supplemented with such serum proteins is unexplained but may be due to the extensive dialysis. The Eagle's formula which we employed did not contain inositol[3] which has been shown to be necessary when extensively dialysed serum is used.

Table 1

Medium Composition	Cell Count*		
	48 hr.	120 hr.	216 hr.
Dialysed Serum 30% (*a*, *b*)	81,000	138,000	221,000
Dialysed Serum 10% (*a*, *b*)	75,000	152,000	169,000
Whole serum 30% (*b*)	80,000	166,000	247,000
Whole serum 10% (*b*)	57,000	172,000	200,000
Eagle's medium 90% Dialysed serum 10% (*a*)	20,000	10,000	13,000

* Average per three tubes.
(*a*) Processed from outdated human blood bank plasma.
(*b*) With yeast extract, 0·2 per cent; Hanks's balanced salt solution

Such dialysed serum preparations have been used exclusively in this laboratory for over a year for the cultivation of HeLa cells with a considerable savings of expense. Large pools of plasma are processed and the resultant serum proteins frozen until used.

This investigation was supported by grant *E*-1678 from the National Institutes of Health, U.S. Public Health Service.

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Age Determination in Wild Rabbits

Population studies of the wild rabbit (*Oryctolagus cuniculus*) in New Zealand and elsewhere have emphasized the need for reliable methods of age determination. Since weight is a satisfactory criterion of the age of young rabbits up to 3–4 months, when they become sexually mature[1]. the sequence of epiphyseal fusion of bones was examined in an attempt to determine the age of older animals. This work was initiated by Watson and Tyndale-Biscoe[2], who found that the epiphysis at the head of the tibia fused at 41 weeks (range 33–44 weeks). Further work by Tyndale-Biscoe[3] (and unpublished work) showed that the epiphyses of all other long bones unite at about the same age or earlier than do those at the head of the tibia, but that the epiphyses of the verte-

bræ do not fuse to the centrum until later in life, and could therefore provide an age criterion for older animals.

An attempt has now been made to determine the timing of epiphyseal fusion of the vertebræ and the extent of individual variation. The ideal method would be to recapture from a wild population, rabbits of known age that had been marked and released when very young; but this was impracticable. No wild population free from control by man was available, and moreover, it would have been necessary to mark very large numbers of young, since only about 2 per cent are likely to survive until 2 years old[4]. For these reasons it was decided to base the work on skeletal material from captive animals of known age. It had been found that growth in captivity did not effect the age of fusion of the tibial epiphyses[2]; likewise, in the present study, the bone fusion of two wild rabbits marked and released as young and recaptured when 16 and 33 months old respectively, was similar to that of captive rabbits of comparable age.

Young wild rabbits were obtained and their age assessed in one of the following ways: (*a*) captured when the tibial epiphyses were still unfused and their age (±6 weeks) determined by recording the time of fusion using X-rays[2-5]; (*b*) dug out of burrows soon after weaning and aged (±1 week) by weight[4]; or (*c*) bred in captivity from wild parents, and exact age known.

In young rabbits the disk-shaped epiphyses are separated by cartilage from the anterior and posterior faces of the centrum. Fusion is a gradual process and all stages exist between epiphyses that are entirely separated by cartilage and those that are indistinguishable from the rest of the centrum. For the present purpose an epiphysis has been considered as fused only when the line of fusion could no longer be detected. The anterior lumbar epiphyses are the first to fuse, followed by the posterior lumbar, anterior thoracic and posterior thoracic, generally in that order. Within each of these groups the epiphysis of the most posterior vertebra fuses first and the others in order anteriorly.

Altogether 47 skeletons of rabbits of known age have been examined, and these are grouped in Table 1

Table 1. Stage of Fusion of Lumbar Vertebral Epiphyses of 47 Wild Rabbits Grouped According to Age

Age (months)	No. examined	No. of rabbits with epiphyses fused: Anterior epiphyses 7	6	5	4	3	2	1	Posterior epiphyses 7	6	5	4	3	2	1
9–14	10														
15–20	13	13	9	6	2										
21–26	11	11	11	10	9	5	4	3	2						
27–32	6	6	6	6	6	6	6	6	6	1					
33–38	7	7	7	7	7	7	7	7	7	6	2	2	1	1	

according to age; the number of rabbits with each lumbar epiphysis fused being shown. The earliest fusion occurred at fifteen months, and although there was considerable variation with age, fusion of the anterior epiphyses progressed anteriorly until all were fused at the age of 25 months. The posterior epiphysis of the 7th lumbar vertebra was first recorded fused at 26 months; and that of the 6th lumbar vertebra at 32 months, and was fused in all rabbits over 34 months old. For practical purposes any rabbit with both epiphyses of the 6th and 7th lumbar vertebræ can be considered as over 33 months of age. In two races of laboratory rabbits complete fusion of all epiphyses is said to occur between 25 and 27 months[6], though this does not appear to take place in the wild rabbit till much later in life.

The present results make it possible to divide a sample of wild rabbits into four age-groups based on the degree of epiphyseal fusion of the tibia and lumbar vertebræ.

(1) Less than 10 months: proximal tibial epiphyses unfused.

(2) 10–25 months: tibia fused, all posterior epiphyses of lumbar vertebræ unfused.

(3) 26–33 months: posterior epiphysis of the 7th lumbar vertebra fused, posterior epiphysis of the 6th lumbar vertebra unfused.

(4) More than 33 months: posterior epiphysis of the 6th lumbar vertebra fused.

Further work is in progress to obtain more precise information on the extent of individual variation, and the ages at which fusion of other vertebral epiphyses occur.

Age determination based on epiphyseal fusion has already been found useful in studies of the reproduction[7] and parasite burden[8,9] of wild rabbits, and also in assessing natural mortality[4] and effects of control measures[10]. The main limitation of skeletal criteria lies in their restricted value for field examination of live animals. However, a completely unfused tibial epiphysis can be felt with the thumb-nail in a living rabbit[2], but unfused vertebral epiphyses cannot be detected in this way, nor are they easily seen in X-ray photographs. On the other hand, a method of age determination based on skeletal features has the advantage that it can still be used long after the death of the animal concerned.

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Asexual Reproduction in the Enchytraeidae (Olig.)

Asexual reproduction has only recently been recorded in the *Enchytraeidae*[1]. This inability of *Enchytraeidae* to reproduce asexually is in sharp contrast with the situation within the families of *Naididae* and *Aelosomatidae*. We have, however, found asexual reproduction to occur in three species of *Enchytraeidae* among the 78 Danish species hitherto examined. In one species asexual reproduction by fragmentation and regeneration is the only mode of reproduction whereas the two other species are able to reproduce sexually as well as asexually.

Cognettia sphagnetorum (Vejd.) augm./Nielsen and Christensen[2] comprises two cytotypes $n \sim 54$ and $n \sim 160$. Asexual reproduction was suspected to occur in this species because sexually mature worms are very rare at any season of the year in spite of the high population densities encountered[3] (about 120,000 per sq. m.); similar densities were found in moorland in Britain (personal communication by Dr. J. Peachey). In the few sexually mature specimens which have

been available for examination it was found that the eggs laid by the 54-chromosome type develop up to a certain stage but that the embryos never hatch; the chromosomes of blastomere mitoses are highly condensed and their number is very variable. In the 160-chromosome type either one or two polar bodies are extruded. In the former case a few cell divisions, with more than 300 chromosomes in the metaphase plates, take place; in the latter case division does not occur, and the pronucleus remains in interphase. In all cases the eggs die within a day or two. In this species sexual reproduction is, therefore, entirely absent and fragmentation is the only means of multiplication. The fragmentation is not preceded by the formation of a special budding zone and the fracture is always located near the middle of a segment. The wound is closed by contraction of the body wall; a blastema grows forward and forms a new body wall, the alimentary canal which becomes attached to the blastema forms a solid strand of cells, at an early stage its dorsal region differentiates into the pharynx; at the same time the brain and blood vessel is formed; when the regenerate has reached a length of about two normal segments, it is sub-divided into 8 segments (sometimes only 7) by transverse grooves visible on the outer surface. Internal septa are formed between segments iv and v and backwards to viii/ix; shortly afterwards septal glands become visible as paired cellular aggregations on all newly formed septa; meanwhile the formation of setæ commences from segment ii and proceeds backwards to viii; the oral opening, buccal cavity and œsophageal lumen are differentiated from the solid cord which represents the prospective alimentary canal; the differentiation is now complete, and the worm begins to feed.

Among a total of 44 immature worms kept in cultures only 5 did not fragment within a month; the remaining 39 yielded 124 smaller fragments, all in the process of regeneration. Direct observations in the breeding chambers[4] showed that the worms divided simultaneously into several fragments: one fragment consisting of the original anterior end which only has to regenerate a new posterior end, a varying number of intermediary fragments which regenerate segments at either end and, finally, the original posterior end. Only the foremost fragment is able to move about immediately after the fragmentation, the others remain immobile for a while and are incapable of moving until the regeneration is nearly complete, thus forming a chain of fragments. Even an intermediary fragment consisting of only two intact segments and half a segment at either end is able to regenerate completely.

In *Cognettia glandulosa* (Mich.) the number of mature worms is high for a short period during the autumn. The chromosome number is $n \sim 54$ and $2n \sim 108$; the eggs develop parthenogenetically and the diploid number is restored by fusion of second polar body and pronucleus. In addition *glandulosa* is able to fragment and to regenerate a new anterior end, as in the former species by the addition of 8 new segments. In breeding experiments running for one month 28 mature worms resulted in 25 worms of normal size, 10 fragments (derived from only 3 worms), 120 cocoons (which were used for cytological purposes) and 30 newly hatched worms.

Buchholzia appendiculata (Buchholz) ($n = 19$ and $2n = 38$) also possesses the ability to fragment and regenerate. Preliminary experiments have shown that the eggs hatch normally, hence, like *C. glandulosa*, this species is able to reproduce both asexually and via eggs but it remains unknown whether it reproduces parthenogenetically.

The three species reproducing asexually represent two different genera but they are unique in having the genital organs displaced towards the anterior end by three or, occasionally, four segments. The ovaries are attached to the posterior side of the septum between segments viii and ix, and the testes to septum vii/viii. The gonads, therefore, always arise from new tissue formed during the regeneration.

The cytology of parthenogenesis and histology of regeneration will be dealt with in greater detail elsewhere.

The work is being financed by a grant from the Danish State Research Foundation, and is a communication from Molslaboratoriet, Femmøller, Denmark and Institute of Genetics, University of Copenhagen.

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Variations in Early Cleavage of the Zebra Fish

Living eggs of the zebra fish, *Brachydanio rerio* (Hamilton, formerly Buchanan), have been studied to detect variations in the rates of cleavage between eggs in the same batch and between different batches. In this tropical fresh-water fish a symmetric pattern of cleavage favours the prompt recognition of impending cytoplasmic furrows up to the 32-cell stage[1], beyond which the stratification of blastomeres and their diminution in size make sufficiently precise observations impossible. Cell division is synchronous in all blastomeres from the 2- to the 32-cell stage.

The stock fish were maintained in aquarium tanks, each sex separately. For any one experiment, eggs were obtained from the mating of one male and one female brought together in a special breeding tank. Egg-laying usually occurs within the 2 hr. after sunrise, and by persistent observation during this time the eggs could be seen dropping through the water or, more usually, at the moment of their arrival on the blackened floor of the tank. Six eggs were transferred to a 'Perspex' observation chamber mounted on a stereoscopic microscope stage. Each egg was placed in a separate concavity in the floor of the chamber, and afterwards could be identified by a letter engraved in the adjacent 'Perspex'. All six eggs could be seen simultaneously in the field of view at magnifications of $\times 8$ or $\times 16$. The transfers must be completed before the first cleavage plane has formed; a period of about 30 min. from laying.

The temperature of the breeding tank was controlled at $27{\cdot}25 \pm 0{\cdot}5$°C. by a mercury-toluene thermoregulator. The observation chamber received its heat from an outer jacket, through which circulated water from an external thermostat controlled by a mercury contact thermometer. The temperature of the water in the chamber was measured to 0·1°C. at frequent intervals throughout each experiment, either by using a copper-constantan thermocouple, or later a thermistor. In both cases a suitable circuit was arranged to show the thermal fluctuations as deflections of a galvonometer needle. The water in the chamber was kept within the limits of $27{\cdot}25 \pm 0{\cdot}5$°C. except during the restoration of water lost by evaporation, when the limits were temporarily exceeded. Rapid cytolysis of whole batches of eggs

during preliminary experiments showed the need for active aeration of the ambient water. This was provided as a stream of air bubbles which by its agitation also facilitated thermostasis.

The galvanometer readings and a coded commentary on the progress of cleavage in each egg were recorded on magnetic tape. An audible time-base, in the form of a 'click' at 30-sec. intervals, was superimposed on the commentary and the base provided with a calibration point, by recording the General Post Office 'speaking clock' once during every uninterrupted run of tape. Using this method, developmental events could be timed to the nearest minute. Since the moment of fertilization was not known, the times of formation of cleavage furrows were measured from the appearance of the first.

The individual developments of 30 eggs have been studied in 5 batches of 6. 8 eggs did not cleave, 21 progressed to the 32-cell stage and beyond, 1 cleaved abnormally with asymmetry. An analysis of variance was performed on the duration times of the 2, 4, 8, and 16-cell stages within each batch. In no batch was there any significant difference ($P > 0.05$) between eggs, so the data within batches were pooled and the mean duration time of each stage for each batch is shown in Table 1. There were, however, significant differences between stages in batch 2 ($P < 0.001$) and batch 4 ($P < 0.01$). The existence of interstage variation made it necessary to compare batches stage by stage. For example, when this was done for batches 1 and 2, by using a t test, a significant difference was found, but only between the 16-cell stages ($P < 0.01$).

TABLE 1

Batch	Number of eggs	Number cleaving	Stage and its mean duration (min.) 2	4	8	16
1	6	3	14·3	15·7	14·7	15·7
2	6	6	14·8	16·8	15·7	17·8
3	6	5	*	14·8	15·4	14·6
4	6	2	16·5	16·5	16·0	12·0
5	6	5	15·8	16·4	15·4	16·0

* These eggs were already in the 2-cell stage when first observed.

The variations may be due to the biological material, the experimental conditions or both. There were differences in parentage, and, perhaps, in preconditioning of the eggs within the ovary. It is also possible that some compensatory control of cell division is operating during cleavage[2]. Records of temperature fluctuations within the desired limits during each experiment, establish the existence of a different thermal history for each experiment and for most eggs (since not all the eggs in a batch develop in phase). Finer temperature control and recording will be necessary to assess the importance of these differences as a cause of variation. It has been shown for sea urchins of the genus *Arbacia* that the oxygen tension has a limiting effect upon the rate of cell division, when the partial pressure in the gaseous phase falls below a value which Amberson[3] places at cell division, when the partial pressure in the gaseous phase falls below a value which Amberson[3] places at 11·5 and Clowes and Krahl[4] at 15 mm. mercury. In the present experiments aeration of the water was as turbulent as was compatible with other requirements.

Cleaving eggs of the zebra fish have been used for the bio-assay of cellular poisons[5]. In any refinements of this technique aimed at quantitative comparison of cytologically active chemicals the possible existence of normal variations should be taken into account.

I wish to thank Mr. G. M. Clarke of the Long Ashton Research Station for statistical advice.

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The Sea Anemone (*Calliactis parasitica*) and the Hermit Crab (*Eupagurus bernhardus*)

IN the well-known associations between hermit crabs and sea anemones, the crab is generally assumed to play an active part in establishing and maintaining the relationship. This has been demonstrated for *Adamsia palliata* and *Eupagurus prideauxi*[1], for *Calliactis parasitica* and *Pagurus arrosor*[2,3], and for *C. parasitica* and *P. striatus*[1,4]. From this it might be expected that the large hermit crab of British waters, *Eupagurus bernhardus*, also actively assists the settlement of *C. parasitica* on its shells. Brief comments in a note by Brightwell[5] and a review by Davenport[6] suggest, however, that these authors never observed such behaviour in *E. bernhardus* since they both state that the belief that this crab places anemones on its shells requires verification.

I have investigated the relationship between these two animals by introducing shells occupied by *E. bernhardus*, and/or unoccupied shells, into containers where a number of *Calliactis* had settled on the walls, floor, or on objects such as stones, scallop shells or slates. Several different experimental arrangements were used, and in all, I recorded about 250 transfers of *Calliactis* to the shells from their original positions. Many of these were followed visually but in no case was a crab seen to play any part in the process. The anemone, by sticking to the shell by its tentacles and spreading the oral disk over a wide area, then detaching the pedal disk and, by bending the column double, bringing the pedal disk over to the shell, climbed on shells entirely unaided by the crab.

The visual experience was confirmed by results which show that *Calliactis* transfer to unoccupied shells just as frequently and as rapidly as they do to shells occupied by *Eupagurus*. In experiments where choices were given, and in successive trials where occupied or unoccupied shells were presented under otherwise identical conditions, there were 153 records of settling on unoccupied, and 146 on occupied, shells. Moreover, *Calliactis* which had settled on unoccupied shells showed no tendency to desert these for occupied shells which were presented later.

E. bernhardus is generally found in empty *Buccinum* shells carrying several *Calliactis*; but living *Buccinum* are seldom found in Nature with the anemone on the shell. Yet in these experiments, *Calliactis* settled very readily on shells of living *Buccinum* and did not desert these later for shells occupied by *Eupagurus* when the latter were introduced.

The tendency for *Calliactis* to settle on occupied or unoccupied shells is abolished if these shells have been thoroughly cleaned by boiling in caustic soda. This indicates that the stimuli which elicit this remarkable behaviour pattern have a chemical component arising from the organic matter adhering to the surface of the shell.

A full account of the work will be published elsewhere. It was done at the Marine Biological Laboratory, Plymouth, and I thank the Director and staff for facilities and help. I also thank the Council of the Royal Society for a grant from the Browne Fund, part of which was used for this investigation.

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Acanthocottus lilljeborgi (Collett) in British Seas

The Norway bullhead, *Acanthocottus lilljeborgi* (Collett, 1875), is a marine cottid (Teleostei-Scleroparei) endemic to the European boreal region. It closely resembles *A. bubalis* (Euphr.) (= *Cottus bubalis* Euphr.) in general appearance, wide attachment of branchiostegous membrane to isthmus, number and arrangement of opercular spines, and possession of a small barbel at each corner of the mouth, but is readily distinguished from *A. bubalis* by the presence of a second longitudinal row of ossicles, dorsal and parallel to that along the lateral line, a difference in pelvic fin formula (I2 instead of I3) and smaller maximum size (60 mm. against 170 mm.)[1]. The distribution and development of *A. lilljeborgi* have been reviewed by Bruun[2,3]. Demersal juveniles and adults of this small fish are not often taken, and most records refer to pelagic postlarvæ. Outside British seas, the species is known from the south and west coasts of Iceland, the Faeroes, Rockall Bank, Great Fisher Bank, the Norwegian coast to 65° N., and the Skagerrak and Kattegat.

Past British records are very few, and bottom living older stages have been recorded only from the Clyde sea area, where small numbers have been found at depths of 10–47 fathoms (18–87m.)[4,5]. The only definite British record of postlarvæ is given by Bal[6], who obtained them off Port Erin, Isle of Man, in May, 1939. However, postlarvæ from the west coast of Ireland (Tory Island and Donegal Bay in the north, Valentia Island in the south) and the east coast of Scotland (St. Andrews Bay and neighbourhood)[7,8], all originally identified as *Oncocottus quadricornis* (L.) (= *Cottus quadricornis* (L.), have been assigned to *A. lilljeborgi* by Bruun.

In the Irish Sea, within the past eighteen months, demersal examples of *A. lilljeborgi* have been taken by scallop-dredge in depths from 15–28 fathoms (28–51 m.) off the south end of the Isle of Man. Standard lengths ranged from 30 to 44 mm. The bottom deposit at the places of capture is coarse, being mainly composed of dead shells and stones, except in one locality where there is a characteristic *Modiolus* epifauna[9]. The relatively wide distribution of the species over this coarse ground, and the evidence of breeding in the region (occurrence of postlarvæ[6] and similarity of some of the demersal specimens to the mature male described by Bruun[2]) suggest that *A. lilljeborgi* is an established inhabitant of the Irish Sea.

I am grateful to Mr. R. G. Hartnoll, of the Marine Biological Station, Port Erin, for providing most of the Manx material, and to Dr. D. W. Tucker, of the British Museum (Natural History), for confirming the identity of four of these fishes.

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Defensive Acid-Secretion in Some Marine Gastropods

It has been known for many years[1] that the opisthobranchiate gastropod *Pleurobranchus membranaceus* (Montagu) is able to produce acid secretions if roughly handled, and the obvious inference is that these secretions deter would-be predators (especially carnivorous fish). More recently, this inference was given a scientific basis in experiments with pleurobranchids and marine fish in the Port Erin Aquarium[2]. During the past few months an attempt has been made to ascertain whether acids were secreted by gastropods other than *P. membranaceus*, and the purpose of this communication is to present some preliminary findings.

It has been found that acid fluids of approximately *p*H 1 can be secreted by the mantle and foot of: *Berthella plumula* (Montagu) (Opisthobranchia: Pleurobranchidae), *Lamellaria perspicua* (L.) (Prosobranchia: Lamellariidae) and *Velutina velutina* (Müller) (Prosobranchia: Lamellariidae). The *p*H estimations were made with Johnson's and B.D.H. *p*H papers. The acid secretion is produced only after rather violent treatment of the area of skin to be tested.

In experiments with hungry fishes (including cod: *Gadus morhua* (L.), pollack: *Pollachius pollachius* (L.), shanny: *Blennius pholis* (L.), father lasher: *Cottus bubalis* Euphrasen and plaice: *Pleuronectes platessa* (L.)), these gastropods were invariably rejected as food. Rejection frequently occurred only after the gastropod had been in the fish's mouth for some seconds. Of the truth of the inference that it is the acid secreted by the gastropods which is responsible for their rejection there can be little doubt, since Bateson[3] found food soaked in a dilute acid for a few seconds to be repellent to a variety of fishes.

One of the most remarkable features of these tests is that the gastropod seldom shows any sign of damage, even though the treatment it appears to receive from the hungry fish is violent in the extreme. It is also worthy of note that the ability to secrete an acid seems to have evolved quite separately at least twice, for the Pleurobranchidae and the Lamellariidae, although superficially exhibiting many parallels, are in the opinion of modern malacologists not at all closely related.

The work here described is financed by a grant from the Leverhulme Trust and is part of an investigation into defensive adaptations in naked gastropods.

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Albinism in Coconut Seedlings

In an article on inducing chlorophyll in albino citrus seedlings, Minessy[1] has recently shown by suitable grafting methods that chlorophyll formation was not blocked in the normal plant and that no chlorophyll irregularities appeared when albinos were grafted on to green ones. He mentions that this result apparently seemed to contradict the somewhat accepted view that albinism is due to recessive genes as was claimed by Torres for the Szinkom mandarin. Several other workers, Patel[2] in the case of the coconut, Bull[3] in the case of the African oil palm, Posnette and Cropley[4] in the case of the strawberry, Rick *et al.*[5] in the case of the tomato, also believed that the cause of albinism was due to certain disturbed genetical factors brought together by cross-pollination. Some botanists have attributed the lack of chlorophyll to infection with an unknown disease. Pretreating citrus seeds with disinfectants such as 'Ceresan' and 'Agrosan' resulted in the production of seedlings which were nearly all green. Albino avocado seedlings were shown by Wallace and Drake[6] to result both from seeds originating from off bloom or late set fruit as well as from matured fruits. Tager and Cameron[7] on the other hand, found that albinism could be eliminated in citrus seedlings by the removal of seed-coats before sowing, indicating that the inhibitor of chlorophyll formation resided in the seed coats. Furtado[2] has mentioned coconut seedlings exhibiting complete shoot albinism, attributing this to some internal factor and chlorosis due to lack of ferrugenous products in the endosperm.

The logical inference from the above review is that there is yet some other factor which induces albinism in plants. Indeed, some of the evidence reported in the case of complete or partial lack of chlorophyll in leaves refers to inadequate functioning of some physiological mechanism essential for the development of plastid colour, a condition which is also brought about by the genetic composition of the plant. That this physiological mechanism appears to be the proper and optimum utilization of iron (and probably nitrogen and magnesium) is apparent from the results we have obtained in several attempts made to induce chlorophyll in albino coconut seedlings. Although calcium, phosphorus and iron do not enter into the composition of the chlorophyll, their variations in the soil are generally known to influence its production. This also appears to depend upon the general vigour and tone of the plant which in their turn are influenced by the optimum availability and/or utilizability of certain combinations and concentrations of these elements.

The albino coconut leaf tissue contained rather high iron and high phosphorus contents. The possibility of preventing the high phosphorus content hampering the availability of iron for the biosynthesis of the pigment, by side-tracking the iron as iron phosphate was, therefore, examined in three ways. Iron (and magnesium) were supplied to the soil every week in the form of chelates (iron green, 330 Fe, NaFe, as well as Na_2Mg) singly and in different combinations to pot-established albino coconut seedlings. Dilute aqueous solutions (2 per cent) were used. It was observed that the central shoots began to develop green colour from about the end of the second week and steadily progressed until the whole leaf appeared healthy and green. The green tint developed from the base of the leaf, proceeding to the tip, petiole and midrib portions almost simultaneously. Even from the time of appearance, the emerging inner shoot had developed chlorophyll just as the normal leaf. Although development of chlorophyll and health of the seedlings progressed with the chelate application, the plants gradually faded and eventually died.

In a second series of experiments the tip of one of the albino leaves was just cut and the cut end kept dipped in a 2 per cent cane sugar solution. On continuing the feeding of the leaf with sugar for a week, it was observed that the inner leaves which developed afterwards had green colour even as a normal leaf. This may be attributed to the organic matter suitably chelating the iron present in the leaf and rendering the nutrients in an available form thus paving the way for normal physiological processes to occur. In the third experiment the cane sugar was substituted by a 2 per cent solution of potassium chloride for the foliar feeding since it is known[8] that iron precipitation by phosphorus could be prevented by a possible conversion of inorganic to organic phosphorus in the leaf and/or by secondary effects on the organic acid status and cell sap *p*H. There was a remarkable response to the potassium treatment in that there was a progressive greening of the inner shoot and inner whorl of leaves.

These results show that inadequate availability iron due probably to the incapacity of the plant to utilize the iron already present in the leaf determines the albinic condition. The requisite mobilization of the iron appears to be the factor controlled by the recessive gene or genes, since albinism is an inherited character. Albinism in the coconut thus appears to follow the general biochemical pattern of nutrient maladjustment which when corrected could orientate the recessive genetical factors to re-adjust properly the physiological processes concerned in the biosynthesis of chlorophyll to their usual and normal courses. Planned experiments to elucidate further these aspects are in progress and will be reported elsewhere.

Our thanks are due to Mr. M. M. Krishna Marar for helpful discussions.

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Capsicum Species of West Africa

There is still considerable confusion in the classification of the genus *Capsicum*. While some authorities disagree as to whether all the cultivated varieties should belong to a single variable species or to the two species, *C. annum* and *C. frutescens* recognized by Linnæus[1–6], others have recognized more species[7,8]. The number of pedicels per leaf axil has been one of the main characters used in the classification of the genus. Recently, Wilson[9], following Smith and Heiser[8], has used 3–5 pedicels at each node and the circular constriction at the base of the calyx in fruit

to distinguish a third species *C. sinense* Jacq. in West Africa.

In the past two years I have collected Nigerian 'peppers' and also have in my collection three types of *C. sinense* Jacq. received, among other species, from the United States by the kindness of Prof. P. G. Smith of the University of California. I have found, under fertile medium and favourable growth conditions both outdoors and in an insect-proof greenhouse, that plants of the *C. sinense* Jacq. type have 1, 2 and occasionally 3 pedicels at each node. I have observed that there are, as a rule, two opposite leaves or stem branching with opposite or near opposite leaves wherever the number of pedicels at each node exceeds 3. Since *Capsicum* plants have alternate leaves, these nodes with opposite or near opposite leaves may be regarded as cases of short internodes[11]. There have not been more than 5 pedicels in any such case. The maximum number of pedicels per leaf axil or true node appears therefore to be 3.

I have also observed circular constriction of the calyx in the fruit of varieties with 1, 2 or 3 pedicels per leaf axil. Varieties with the constriction commonly have the greenish yellow or greenish white corolla typical of *C. frutescens* L.

Although embryo abortion of the 'somatoplastic sterility' type[10] has been found in some crosses of *C. annuum* L and *C. frutescens* L, the two commonly recognized species of the genus, the species are, however, not completely intersterile, and their F_1 hybrids have shown regular pairing suggestive of homologous chromosomes[11]. So far I have found no cause to think that the reported sterility barrier between *C. sinense* Jacq. and *C. frutescens* L, which it resembles in every aspect, approaches the degree of intersterility found between *C. annuum* L and *C. frutescens* L. The basis of separation of *C. sinense* Jacq. as a distinct species from *C. frutescens* L appears rather inclusive at least in the West African species. Now that the species *C. abyssinicum* A. Rich; *C. baccatum* L. Holl; and *C. cordiforme* Mill. listed for West Africa[12] are no longer regarded as distinct[13], it is suggested that until further work provides conclusive evidence of the existence of other species, the West African 'peppers' should be limited to *C. annuum* L. and *C. frutescens* L. on the following basis: *C. annuum*, usually 1 and rarely 2 pedicels per leaf axil; white corolla. Generally has thrifty growth for one season. *C. frutescens*, frequently 1 and 2, and occasionally 3 pedicels per leaf axil; light greenish yellow to greenish white corolla. Generally has thrifty growth for more than one season.

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ENTOMOLOGY

Central Control of Interactions between Behaviour Patterns in a Hemileucine Moth

Previous publications have described the relation between precurrent flight performance and the strength of a subsequent rhythmic settling response ('rocking') in the neotropical saturniid moth *Automeris aurantiaca* Weymer (Hemileucinæ[1])[2]. The strength of the rocking response, measured as the number of complete oscillations of the rhythm, increases linearly with duration of flight, and in the absence of further flight responses is stable to retesting for periods of at least 90 min. The mechanism by which flight performance is thus registered and expressed in the subsequent settling behaviour is of particular interest, for the relationship is similar to that between the flight activity of foraging honey-bees, and the rhythmic distance-specific components of the communication dance[2].

Three factors other than flight duration influence the strength of the rocking response: (1) age from eclosion; (2) the presence of competing reproductive responses, themselves released by precurrent flight[3], which may be eliminated by removal of the abdomen, either before flight, or between flight and testing; (3) the proximity in time between flight and the settling response; close temporal proximity between the two acts tends to diminish the strength of the rocking response.

If these three factors are controlled by appropriate techniques, the number of oscillations which will be performed after a given duration of forced, tethered flight[2] can be predicted within very narrow limits.

The following operations performed before flight fail to interfere with the process of registration: (1) removal of the antennæ, including Johnston's organ, followed by the ablation, by scraping, of the wind-sensitive hairs of Eltringham's organ, and the painting of the entire head with a layer of shellac varnish; (2) section of the indirect flight muscles, with or without bilateral excision of the wing-bases, and removal of the abdomen. Thus neither exteroceptive nor proprioceptive feed-back from flight-performance can mediate registration. This conclusion is reinforced by the fact that registration proceeds at the same rate in free-flying and tethered, de-alated moths.

After flight, (3) removal of the abdomen, followed by perfusion with Ringer's solution alone, and with amounts of up to 60 gm./l. of added glucose or trehalose fails to interfere with the stability of the response, even after recovery from the osmotic shock caused by the stronger solutions. Since the mouth-parts are vestigial, and the moths do not feed, these perfusion tests confirm that registration cannot be mediated by the interoception of the state of metabolic reserves.

The mere removal of tarsal support in the absence of an ensuing flight response is insufficient to induce registration. No afferent pathways other than those implicated by the release of flight need to be stimulated for registration to take place; moreover, activation of the central neural units which mediate the excitation and maintenance of flight is a necessary part of the process.

For technical reasons, it is unlikely that experiments of this type can be applied to the honey-bee communication dance, even in more moderate form. Nevertheless, the present results allow a strong presumption that the distance-specific components of the bee's dance may be controlled by similar

central interactions. Such a hypothesis at least has the merit of economy, in comparison with the alternative hypotheses requiring feed-back from the metabolic or aerodynamic consequences of flight[4].

Part of this study was made possible by a grant to the Smithsonian Institution, Washington, D.C., from the U.S. National Science Foundation, which facilitated field work in the Panama Canal Zone.

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Insecticidal Effects of Activated Charcoal and Clays

BRISCOE[1], Kitchner *et al.*[2], Wigglesworth[3], and Parkin[4] have studied the 'inert' dusts for their insecticidal action. Reports on the insecticidal properties of 'inert' dusts, particularly of silica, coal ash, diamond, 'Carborundum', dusts from blast furnaces, flint, felspar, magnesite and dolomite are available[1,2,4]. While screening samples of various clays, decolourizing carbon, gas absorbing carbon, silica gel and commercial soil conditioners for insecticidal effects, it was observed that most of the dusts passing through a 300-mesh had various degrees of insecticidal effects on *Tribolium casteneum* Hbst. adults; but activated charcoal and decolourizing clays exhibited, in general, quicker effects on insects than unactivated dusts. Samples of wood shavings, sawdusts, coconut shells and kaolinic clays were activated therefore, for further studies on their insecticidal properties. Activated charcoals were prepared by the zinc chloride activation method[5] and kaolinic clays were activated by acid treatment[6].

Dusts passed through a 300-mesh were used for this work. The insecticidal properties of the activated and inactivated samples were tested against *T. casteneum* by releasing adults on the dusts applied on glazed porcelain test plates and enclosing them in glass rings for different exposure periods. At the end of exposure periods, mortality counts were recorded. Gas-absorbing capacities of the samples were determined by Mantell's method[7]. Decolourizing properties of charcoal samples were determined by suspending 0·1 gm. samples in 10 ml. of 0·01 per cent methylene blue solution in distilled water for 30 min., and per cent transmission readings were taken in a Lumitron photoelectric colourimeter using a 650-mμ filter on the filtered aliquot diluted to 10 times its volume with distilled water. Bleaching qualities of clays were assessed by the method of the American Oil Chemists' Society[8]. The results obtained with the activated and inactivated charcoal and clay samples on their gas-absorbing, decolourizing and insecticidal qualities are presented in Tables 1 and 2.

Activated charcoal and clay samples showed, in general, high degrees of insecticidal activity (Tables 1 and 2). On activation the gas-absorbing capacity was increased in the samples as compared with the inactivated samples. The decolourizing property was also improved by the activation treatments of the charcoal and clay samples. The results indicated that the insecticidal potency of the dusts is related to either the decolourizing property or the gas absorbing capacity or both. These aspects require further elucidation. Activated charcoals were found to be better insecticides than the activated clays or silica gel. In our experiments, gas-absorbing carbon of the type used in a gas-mask canister resulted in 100 per cent mortality of the test insects within 4 hr. exposure; while the inactivated charcoals from different timbers gave 30 per cent or less mortality even after 24-hr. exposure of the test insects. The clays on activation exhibited high degrees of insecticidal properties although the inactivated parent materials did not show appreciable insecticidal actions (Table 2). However, prolonged exposures of 24 and 48 hr. on inactivated clays and 6 days post-exposure incubation of the test insects on wheat flour, resulted in 10–80 per cent mortality.

In a further study, it was interesting to note that activated charcoal samples exhibited comparatively

Table 1. INSECTICIDAL, GAS-ABSORBING AND DECOLOURIZING PROPERTIES OF CHARCOAL SAMPLES

SAMPLE	Mortality % *T. casteneum* exposure (hr. at 26°C., 68% R.H.) 4	8	16	24	CCl_4 adsorptive capacity gm./gm. of charcoal, 25°C.	*Decolourizing power, 'Lumitron' % Transmission, 650 mμ filter
Canister carbon 1	100	100	100	100	1·26	100
Canister carbon 2	46	68	100	100	0·95	100
Activated carbon (Merck)	28	79	100	100	0·79	100
Coconut shell carbon (*I.A.*)	0	0	0	30	0·07	21
Coconut shell carbon (*A.*)	30	75	100	100	0·74	96
Dalbergia latifolia charcoal (*I.A.*)	0	0	0	28	0·05	20
Dalbergia latifolia charcoal (*A.*)	30	54	83	100	0·62	61
Tectonia grandis charcoal (*I.A.*)	0	0	0	20	0·04	18
Tectonia grandis charcoal (*A.*)	25	30	68	100	0·59	54
Anogeissus latifolia charcoal (*I.A.*)	0	0	0	30	0·50	20
Anogeissus latifolia charcoal (*A.*)	0	12	23	66	0·50	24
Coal (*I.A.*)	0	0	0	0	0·03	18

I.A., inactivated; *A.*, activated; * 14 (control)

Table 2. INSECTICIDAL, GAS-ABSORBING AND BLEACHING PROPERTIES OF CLAYS

SAMPLE	Mortality % *T.casteneum* exposure in hr. (hr. at 26°C., 68% R.H.) 4	8	16	24	CCl_4 adsorptive capacity gm./gm. of clay, 25°C.	% Bleaching of refined groundnut oil, 0·5 gm. clay in 10 ml. oil
Fuller's earth (natural)	0	0	0	0	0·12	13
Fuller's earth (activated)	0	0	96	100	0·63	31
Bageshpura clay (natural)	0	0	0	0	0·01	23
Bageshpura clay (activated)	0	12	89	100	0·21	40
Ball clay (natural)	0	0	0	10	0·03	27
Ball clay (activated)	0	48	95	100	0·32	40
Hebbur clay (natural)	0	0	0	10	0·02	24
Hebbur clay (activated)	0	43	92	100	0·24	32
Silica gel (heated at 110°C.)	0	40	65	91	0·30	17

high levels of insecticidal activities even at 95 per cent relative humidity and 30°C. against *T. casteneum* adults than other test materials.

The widely accepted concept of the insecticidal actions of inert dusts centres around the desiccation theory developed by Germer[9]. As a general rule, the insecticidal effectiveness of the inert dusts increases with the fineness of the particles and hardness number. The hardness number of 6 or above in Moh's scale and size of particle below 10μ are considered to be the prerequisites for the insecticidal property of the *inert* dusts. But in the present investigation the dusts tested are of materials having hardness number below 6 in Moh's scale. This investigation reveals the fact that the charcoal and clay samples which are of comparatively low insecticidal value can be converted to highly insecticidal materials by activation treatment. Experiments are in progress on the processing techniques and the mode of insecticidal actions of these active dusts.

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A Simplified Method for the Culture of *Blatella germanica* under Aseptic Conditions

In developing the work recently begun in this laboratory[1] on the sterol metabolism of the German cockroach, *Blatella germanica*, it has become necessary to use aseptic techniques as an aid in defining the metabolic contribution of the normally occurring microbial inhabitants of the gut of the insect. The technique for the aseptic culture of this insect which has been described[2] entails the use of a watering device which is of undesirable complexity, while simpler devices[3] which could be adapted for aseptic work involve the renewal of a sterile water-supply at intervals throughout the experiment. Since these feeding experiments frequently last for three months or longer the risk of contamination during opening the culture vessels, especially in a laboratory not fully equipped for aseptic work, becomes quite high. I have therefore devised a simple procedure which has made it possible to rear healthy colonies of German cockroaches aseptically in glass jars without the need of opening them for at least five months and which could well be used for maintaining colonies undisturbed for twice this length of time. The method also provides for the sterility testing of the young nymphs without the necessity of opening the hatching tubes for removal of inoculation samples.

The mature oothecæ are taken from the female cockroach at the time when the green yolk line becomes clearly visible and are sterilized essentially by Gier's method[4] with the use of a sterile box. Immediately after sterilization each individual ootheca is placed in a hatching and sterility testing tube made up as follows:

10 ml. of a sterility testing agar consisting of thioglycollate test medium (Difco No. *B*430) made up in 2 per cent aqueous agar solution is poured into a boiling tube 150 × 25 mm. A small test-tube 50 × 13mm. is placed in the medium inside the boiling tube which is then plugged with cotton-wool and covered with a brown paper cap before being sterilized by autoclaving. On cooling, the nutrient agar solidifies around the small inner tube. Working in the sterile box, the cotton plug is removed from the boiling tube and a sterilized ootheca is dropped into the small inner tube. The cotton plug and paper cap are replaced and the tube set aside in the insectory to incubate at 27° C. and 60–70 per cent relative humidity. The young usually hatch within 2–10 days, depending upon the stage of maturation of the oothecæ at the time of collection. After emergence, the young nymphs are kept in the hatching tube for 4 days. During this time they eat from the surface of the nutrient agar and contaminate it with fæcal pellets. Failure of fungal or bacterial growth to appear on the test agar during the 4-day test period is taken as an index of asepsis of the colony which is then deemed suitable for use in long-term metabolic experiments.

For long-term culture the nymphs are transferred under carbon dioxide anæsthesia (applied by allowing the gas to diffuse through the cotton plug of the hatching tube) to 32-oz. wide-mouthed glass bottles prepared as follows:

150–200 ml. of hot 2 per cent agar solution in distilled water is poured into the bottle and the experimental diet placed in a boiling tube which in turn is placed upright in the bottle. The bottle is now plugged with cotton and covered with a brown paper cap before being sterilized in the autoclave. After sterilization the bottle and its contents are allowed to cool in a tilted position so that the tube containing the diet comes to be firmly held against the wall of the bottle by the solidified agar and is thus prevented from rolling and thereby damaging the insects. The sterile, anæsthetized insects are transferred to their new quarters with the use of the sterile box. As an assurance of continued asepsis following this transfer a small slab (25 × 15 × 5 mm.) of solid sterility testing agar of the composition described above is cut and placed on the inner wall of the vessel before it is re-plugged, covered again with paper and placed lying on its side in the insect room for as long as the experiment requires. At the termination of the feeding experiment sterility is again tested by inoculation of the insect fæces into fluid sterility test media or on to nutrient agar plates.

Colonies set up in this way require no attention beyond the usual maintenance of temperature and humidity conditions and are in fact more resistant to chance falls in ambient humidity than insects maintained under more usual conditions, since their immediate environment is well supplied with moisture. Under 70 per cent relative humidity, the solid agar contains sufficient water to supply the growing colony (20–30 cockroaches) for several months. I have several colonies which have been kept under these conditions for five months on various diets but principally on the synthetic diet of Noland and Baumann[5]. The insects have matured and reproduced normally though with the somewhat longer maturation time reported by other workers for growth under aseptic conditions[6,7].

The same procedure has been used successfully for

the establishment of aseptic colonies of *Eurycotis floridana*: but on attempting to apply it to *Blatta orientalis* no oothecæ have been found to hatch. Presumably the sterilizing media can penetrate the oothecal capsule in this species and cause the death of the developing young.

It is recognized that the procedure described may have a disadvantage for some types of nutritional study in that the insect consumes an undetermined amount of solid material in using the agar gel as a source of water. On the other hand, the solid experimental diet is consumed at an undiminished rate as compared with more conventional feeding conditions and the method is particularly suitable for studies of the metabolic fate of specific dietary constituents. The results of these metabolic experiments will be reported in detail elsewhere.

I wish to thank Prof. Konrad Bloch for his interest in this work which was supported by a grant from the National Institutes of Health.

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Blood-feeding Habits of Adult Noctuidae (Lepidoptera) in Cambodia

Previous observations on feeding habits of the genus *Arcyophora* were summarized by Reid[1]. Only in African territories adult moths were found feeding nocturnally on the lachrymal secretions of cattle, horses, mules, donkeys and wounded antelopes. One particular observation was made by Neave (quoted by Reid[1]) in South Africa, where many moths were sucking fluid, but no blood, from the eyes of a wounded animal.

During a recent assignment in Cambodia, entomological night collecting was carried out which led to the discovery of the blood-feeding habits of *Lobocraspis griseifusa* Hmpsn. Another less-common species, namely *Arcyophora silvatica* sp. nov. was associated with *L. griseifusa*.

In order to obtain direct evidence of blood meals taken by the moths, dissections of stomach contents were carried out at Kbal Trach (near Snoul, Cambodia) in the night of June 29-30, 1958. In a first series of 8 females of *L. griseifusa* collected early in the evening from water buffaloes, no blood-feeding but only watery fluid was found. In a second series, two specimens were found with traces of blood which were used for microscopic slides stained by the J.S.B. staining technique. The examination revealed the presence of red blood corpuscles in an advanced stage of digestion. Further 15 samples were obtained from the digestive system of males and females of *L. griseifusa* and used for precipitin tests at other occasions. In these cases they were found to be positive for bovines.

So far as the observations on *L. griseifusa* and *Arcyophora silvatica* are concerned, very little irritation seems to be caused on their hosts by these insects. While feeding, the proboscis of the moth is inserted between the lid and cornea of the eye and feeding extends over several minutes. Investigations on the possible role as vectors of contagious bovine diseases are indicated. A more detailed account of these results will be published elsewhere in due course.

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MICROBIOLOGY

Effects of Deuterium Oxide on the Synthesis of T5 and T7 Bacteriophages

Early experiments on the biological effects of deuterium oxide indicated that the substitution of the pure substance for water resulted in cessation of growth in such diverse biological entities as tobacco seeds[1], flatworms[2], and mice[3]. When there was partial substitution of water by heavy water, growth was merely retarded. This retardation was attributed to an isotope effect resulting in lowered rates of reactions involving deuterium as compared to hydrogen[4]. The inhibition of tumour growth in animals the body water of which contained appreciable amounts of deuterium[2,6] is another striking example of an isotope effect in which retardation of a biological reaction has been observed. Similar isotope effects have been observed in photochemical reactions[4] as well as in yeast fermentation[7].

Cells of *Escherichia coli*, strain *B*, were raised in double-strength nutrient broth containing 0·5 per cent sodium chloride and 0·001 *M* calcium chloride. Deuterated medium was prepared by mixing equal volumes of a nutrient broth concentrate and 99·74 per cent pure heavy water. One-step growth-curves of the bacteriophages were performed by an established technique[8]. The exposure of infected cells to heavy water was accomplished by rapidly diluting the cells in deuterated medium after the adsorption period. The adsorption period was 10 min. with *T5* and one minute with *T7*.

As seen in Table 1, the addition of various amounts of heavy water to growth media caused marked effects on the lag period and the mass doubling time of the bacteria. Cells grown in 50 per cent heavy water appeared larger than did water-grown cells; and by 18 hr. many of the cells grown in heavy water were long and filamentous.

The effects of heavy water on the burst sizes of *T5* and *T7* bacteriophages are shown in Table 2. Heavy water present during the latent period decreased the burst size with *T5* but had no significant

Table 1. The Effect of D_2O on the Growth of *E. coli*, Strain B

Per cent D_2O in growth medium	Time (minutes) Lag	Mass doubling time	Final population (Per cent of control)
none	30	30	100
10	60	33	100
25	60	40	96
50	60	60	92

Table 2. Effects of Heavy Water on the Burst Sizes of *T5* and *T7* Bacteriophages

Heavy water in growth medium (%)	Heavy water in medium during latent period (%)	Burst Size* *T5*	Burst Size* *T7*
0	0	100	100
0	50	50 ($P=0·1$)	124 ($P=0·9$)
50	0	76 ($P=0·2$)	199 ($P=0·1$)
50	50	102 ($P=0·9$)	134 ($P=0·02$)

* Values expressed as per cent of control, water-grown infected cells exposed to water during the latent period. The average burst for *T5* was 226 and for *T7*, 209.

effect on *T*7 multiplication. Infected cells grown in heavy water incubated in normal media show a decreased burst size of questionable significance with *T*5 and a marked increase with *T*7. When the infected cells were both grown and incubated in media containing heavy water, *T*5 multiplication was normal whereas the burst size observed with *T*7 was significantly increased. With each bacteriophage the latent period was significantly lengthened.

It is known that the medium contributes heavily to the synthesis of *T*5 deoxyribonucleic acid[9] while such is not the case with *T*7[10]. Thus it is not surprising that *T*5 multiplication is affected when heavy water is present in the medium during the latent period. It is possible that the increased size of cells grown in heavy water is responsible for the increase in burst size seen with *T*7. Experiments to elucidate the nature of the observed effects are in progress.

This work was supported by the United States Atomic Energy Commission, Contract No. *AT*(30-1)-2299.

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Galactose-sensitive Mutants of *Salmonella*

In a previous communication[1] peculiar mutants of *Salmonella* were described, which had been originally discovered and called 'mutabile-type' (*M*) by Murase[2]. These mutants, when grown in the presence of low concentrations of galactose, show a marked lysis in ordinary media, and are converted to 'protoplasts' in hypertonic media. Moreover, they are consistently non-fermenters of galactose.

We have recently studied the location of the enzymatic block in the metabolism of galactose. The strains used were, *Salmonella enteritidis* No. 11 (wild type), 11-1-*M* (*M* mutant derived from No. 11), 11-1-*TB* and 11-1-*TW*. The last two strains were galactose-negative, galactose-resistant mutants derived from 11-1-*M*. The results of the studies of galactose metabolism are summarized in Table 1. To measure the consumption of galactose, 5×10^{-4}*M* galactose was added to the growing cells in citrate-ammonium medium. Aliquots were deproteinized by barium hydroxide followed by zinc sulphate, and the reducing sugar was determined. The slow utilization of galactose by *M* and *TB* cells is not merely due to the simple intracellular accumulation since treatment at 100°C. for 2–3 min.[3] before deproteinization did not alter the results. Then the enzymes on the Leloir pathway[4] were studied.

Table 1. The metabolism of galactose by various mutant strains

Strain	No. 11	11-1-*M*	11-1-*TB*	11-1-*TW*
Lysis by galactose*	—	+	delayed	—
Acid production from galactose†	+	—	—	—
Consumption of galactose (μmoles/100 mgm. dry weight cells/30 min.)	>75	20·5	6·4	0
Activity of galactokinase‡ (μmoles/100 mgm. acetone-dried cells/30 min.)	53·5	21·4	4·3	0
Accumulation of Gal-1-P (μmoles/100 mgm. dry weight cells/30 min.)	0	1·20	0·87	0
Activity of transferase	+	+	Not examined	
Activity of epimerase	+	−		

* Tested in broth with 0·1% galactose.
† Tested on BTB-galactose agar.
‡ The reaction mixture contained 10 μmoles galactose, 4 μmoles adenosine triphosphate, 10 μmoles magnesium chloride and 60 μmoles sodium bicarbonate in 2·0 ml. The gas phase was 80 per cent nitrogen –20 per cent carbon dioxide.

$$\text{galactose} + \text{adenosine triphosphate} \rightarrow \underset{\text{(galactokinase)}}{\text{galactose-1-phosphate}} + \text{adenosine diphosphate}$$

$$\text{galactose-1-phosphate} + \text{uridine diphosphoglucose} \rightleftharpoons \underset{\text{(galactose-1-phosphate uridyl transferase)}}{\text{glucose-1-phosphate}} + \text{uridine diphosphogalactose}$$

$$\text{uridine diphosphogalactose} \rightleftharpoons \underset{\text{(uridine diphosphogalactose-4-epimerase)}}{\text{uridine diphosphoglucose}}$$

The activity of galactokinase was determined manometrically on the acetone-dried preparation of the cells induced for 30 min. by 0·1 per cent galactose in plain broth. *M* cells had plenty of galactokinase; but its activity was lower in the galactose-resistant mutants. Then, it was found that a compound containing acid-labile phosphate was accumulated in *M* cells grown in the presence of galactose. This compound behaved in exactly the same way as the authentic sample of galactose-1-phosphate on paper chromatography with various solvents (including that of Harrap[5] which was found to be able to separate clearly galactose-1-phosphate from glucose-1-phosphate). When the accumulation of galactose-1-phosphate was determined as acid-labile phosphate which was not adsorbed by charcoal, it was found to be less in resistant strains than in *M* cells. These results show that: (1) *M* mutants have high levels of galactokinase, but are blocked in the later step of galactose metabolism as is evident from the accumulation of galactose-1-phosphate; (2) lytic effect is correlated with the metabolism of galactose by galactokinase, because the less galactokinase a strain has, the more does it seem to be resistant to galactose.

To determine the presence of galactose-1-phosphate uridyl transferase (transferase), the induced cells were extracted by grinding with alumina and the extract was incubated with galactose-1-phosphate (0·2–0·4 μmole), uridine diphosphoglucose (0·05–0·1 μmole), tris buffer (*p*H 8·7), magnesium chloride, cysteine and crystalline phosphoglucomutase. Phosphoglucomutase was to convert the produced glucose-1-phosphate to glucose-6-phosphate. After deproteinization with 0·5*N* perchloric acid, the formation of glucose-6-phosphate was determined as the disappearance of acid-labile plus inorganic phosphate during the incubation. By this method, abundant transferase was demonstrated in wild-type cells. With the extract of *M* cells, the reaction proceeded rapidly at first, but it soon reached a plateau, and the total amount of the product formed was far less than the amount of galactose-1-phosphate added. Since in this assay system, uridine diphosphoglucose added in catalytic amount should be quickly consumed if it was not regenerated by uridine diphosphogalactose-4-epimerase (epimerase), this observation suggests the presence of transferase and the absence of epimerase. Furthermore, the following results confirm this interpretation. (1) If substrate amount of uridine diphosphoglucose (0·8 μmole) was used, almost complete utilization of galactose-1-phosphate was observed. (2) The extract of a mutant of *E. coli K*-12

(*W*-3096)[6], which by itself did not show any detectable transferase activity but is reported to contain abundant epimerase[7], was able to allow the reaction to completion with the catalytic amount of uridine diphosphoglucose, if combined with the extract of *M* cells. (But the former loses its catalytic activity when treated for a few minutes at 100°C.). Thus it seems now obvious that *M* cells have a block at the epimerase level. This is in contrast to the transferase-less mutants of *E. coli*, which are reported to show marked bacteriostasis but *not* lysis in the presence of galactose[7]. We were very recently informed by Dr. H. M. Kalckar[8] that he also had independently demonstrated by his more specific method of assay, that the metabolic block of one of our *E. coli M* mutants lies at the level of epimerase.

Since epimerase is believed to be responsible also for the biosynthesis of galactose, the sugars in the cell wall hydrolyzate were analyzed by paper chromatography. It was found that wild-type cells contain a large amount of galactose in addition to glucose and rhamnose; but *M* cells did not contain galactose and rhamnose at all. This is in agreement with the recent report of Kalckar and Kurahashi[7] that their *E. coli* mutant *W*-3099, lacking epimerase, transferase and galactokinase, does not possess galactose and rhamnose in its polysaccharides. In the light of this finding, some peculiar features of *M* cells become intelligible. *M* cells form somewhat rough colonies, they have greatly altered susceptibility to phages. In the transduction using temperate phage *PLT*-22 and *M* mutants of *Salmonella typhimurium LT*-2 and *LT*-7, these various characteristics behaved all together with sensitivity to and non-fermentation of galactose. These characteristics had been interpreted as the pleiotropic expression of a single gene mutation, but they can now be considered as solely due to the abnormal composition of the cell wall induced by the primary defect in epimerase, and it serves to demonstrate how far-reaching the effect of a single enzymatic defect could be.

The mechanism of lysis has not yet been elucidated. But considering the results[9] which show that the synthesis of neither cell wall lipocarbohydrate nor cell wall protein is quantitatively impaired by the presence of galactose, the simple inhibition of cell wall synthesis[1] seems rather unlikely. In the *M* mutants of *S. typhimurium LT*-7, which cannot adsorb phage *PLT*-22 in contrast to wild-type cells, galactose appears to induce the de novo formation of 'normal' phage receptors[9]. It might be considered that the 'incompatibility' between the newly formed 'normal' cell wall and the pre-existing 'abnormal' one might be the direct cause of lysis by galactose.

Thanks are due to Drs. H. M. Kalckar and K. Kurahashi, for valuable suggestions and for supplying chemicals and mutant strains of *K*-12, and also to Prof. D. Ushiba for helpful discussions.

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Factors in Forest-Tree Litter Extracts affecting the Growth of Soil Micro-Organisms

It is well known that beech litter is less susceptible to decomposition than is the litter of many other species including maple. One reason for this may be the presence or absence of certain factors inhibiting or stimulating microbial growth. For example, factors inhibitory to various fungi have been shown to occur in leaf exudates of certain plants[1] and in many plant extracts[2,3,4] whereas factors stimulating certain mycorrhizal and saprophytic Hymenomycetes have also been observed[3]. Antibacterial factors have been demonstrated in extracts of oak and maple leaves[5], spruce needles[6], and in other species[7]. Autoclaving of the extract has been shown to increase the inhibition of fungi[3] and bacteria[5] under the experimental conditions used.

Rather different properties of inhibition and stimulation were observed in the following study in which newly fallen beech (*Fagus grandifolia*) and maple (*Acer saccharum*) leaves were extracted with cold water. The dried leaves were milled, homogenized with ten times their weight of cold water, filtered and then centrifuged to remove suspended organic material. The *p*H was adjusted to 6·8, and half of the extract sterilized by Seitz-filtration and the remainder by autoclaving. Medium consisting of equal quantities of Difco nutrient broth and leaf extract was then inoculated with each test organism (Table 1). Fungi were incubated for 20 days and growth determined by dry-weight measurements. Bacteria were incubated for two days and growth estimated by plate counts. The results are shown in Table 1.

The fungi showed similar growth responses as also did the bacteria but the two groups differed from each other. Thus the fungi alone were inhibited by the filtered extract but only that prepared from beech leaves was active in this way. The bacteria, however,

Table 1. Growth of Four Micro-Organisms in Nutrient Broth Containing Tree Leaf Litter Extracts Sterilized in Two Ways.

	Control water	Beech Seitz-filtered	Beech Auto-claved	Maple Seitz-filtered	Maple Auto-claved
Rhizopus nigricans mgm./25 ml.	4·1	1·1	24·4	8·2	15·7
Aspergillus niger mgm./25 ml.	7·4	1·7	31·4	41·1	38·7
Azotobacter sp. No. × 10^6/ml.	67	325	1	286	0
Pseudomonas fluorescens No. × 10^6/ml.	179	515	14	435	0

were inhibited strongly by both autoclaved extracts which were stimulatory to both fungi tested. The significance and mechanism of the apparently separate bacterial and fungal inhibitors must await further investigation, but it is conceivable that the fungistatic activity of the filtered beech extract may have ecological significance in the field.

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FISHERIES

Prediction of Selection Factors in a Tropical Trawl Fishery

The discovery of a potential trawl fishery in an under-developed region may lead to the rapid expansion of the mechanized fleet and the exhaustion of the resource in a very few years; this has recently occurred in Liberia[1] and appears to be happening in Ghana[2]. If it were possible, in the early stages of development, to introduce appropriate mesh-size regulations (together with a vessel-licensing system) the exploitation of the resources might be placed on a more rational basis; but it is characteristic of such a situation both that the research facilities are limited and that the exploited stocks comprise a variety of species, each of which will be selected differently by a particular mesh-size. Devold[3] comments on such a situation, which has now arisen through the introduction of modern trawlers on the Brazilian coast.

As an interim measure, and as an alternative to legislation by intuition, the derivation of selection factors (S) from the length/girth (L/G) relationship appears to be promising. Graham[4] commends such a derivation, but the relationship between L/G and S appears to have been little investigated; Margetts[5] has made an indirect approach in the case of European haddock and whiting, while Cassie[6] has made a direct comparison for the New Zealand snapper. Cassie postulated that the 50 per cent retention length (L') for snapper would be close to the length appropriate to a girth equal to the circumference ($2M$) of the mesh under consideration; for this species the calculated, or predicted, value of S was 2·35, the best experimental estimate 2·32, the mean experimental estimate for single twine cod-ends 2·35. Agreement was thus much closer than in the case of Margetts's work, which was based on much more sensitive girth measurements and calculations, but where the best estimate of S for haddock was 4·06, against the value currently accepted by the International Council for the Exploration of the Sea of 3·30.

For Cassies's postulate to be generally true it must be possible for a normally active fish seeking to escape from a trawl net to expand the diamond shape of the mesh nearly to its maximum area; an experiment in which a trawl net was anchored at the surface in a 2–3 knot tideway has shown that the force necessary to thrust a greased wooden cone through the mesh to its full expansion is surprisingly small—a sudden thrust of 2 kgm. would appear to be within the powers of an active 10–12 in. teleost, and expands the mesh (in this case of single cotton twine) to within 7 per cent of the maximum possible without pulling the knots.

The L/G ratios of the more important demersal fish off Sierra Leone have been investigated and it is now possible to draw up a table of predicted values of S for these fish, based on the calculation $S=L'/M$, L' being derived either from the equation $L=nG+k$ obtained by least squares in the case of good samples, or $L=nG$ in the case of small samples. These values are given in Table 1.

Concurrently with this investigation, covered cod-end experiments have been started using an open 28-ft. trawler; these will presumably require several years for completion, but preliminary data make possible an estimate of the accuracy of the predictions for two species. In the case of gwangwa the agreement between the two values is very close (Table 2) but in the case of crocus (etym. 'croakers', Creole?) the experimental value of 3·45 for a small sample of 338 fish is not very close to the prediction—though even so the value of L' for the mesh used is within 5 per cent of that predicted (19·5 against 21·3 cm.).

Table 1. Predicted Selection Factors for West African Demersal Fish, for a Relatively Flexible Mesh of Such Material as Cotton, Manila or Nylon.

Sheephead (*Drepane africana*)	1·41
Spadefish (*Ephippus lippei*)	1·44
Catfish (*Tachysurus gambensis*)	1·91
Snapper (*Pagrus ehrenbergi*)	2·49
Crocus (*Pristipoma jubelini*)	2·89
Shinenose (*Galeoides decadactylus*)	3·30
Gwangwa (*Pseudotolithus elongatus*)	3·58
Ladyfish (*Pseudotolithus senegalensis*)	3·66
Whiting (*Pseudotolithus senegalla*)	3·71
Spanish (*Polydactylus quadrifilis*)	3·92
Tenny (*Elops senegalensis*)	4·22
Ladyfish (*Pseudotolithus macrognathus*)	4·26
Sole (*Cynoglossus goreensis*)	4·56

Table 2. Predicted and Experimental Retention Data for Gwangwa.

		N	M	S	L' 0%	L' 50%	L' 100%
Series *A*	Exp.	2738	6·70	3·47	(13·0)	23·25	27·0
	Pred.			3·48	13·0	23·33	31·49
Series *B*	Exp.	2076	6·79	3·49	(12·0)	23·75	28·0
	Pred.			3·47	13·23	23·61	31·87

Series *A*, 10 hauls; series *B*, 16 hauls, totalling together 40¼ hr. trawling time in the Sierra Leone estuary. N, number of fish in each series, M, mesh in cm., L', percentage retention length in cm.

The disparity between the predicted values for gwangwa in Tables 1 and 2 arises from the fact that over the size range of fish examined the slope of L/G has a significant positive intercept—so that the value of S will vary slightly with the mesh size. Table 1 is based on mean figures for 1-, 2-, 3- and 4-in. meshes and Table 2 on 6·70- and 6·79-cm.meshes.

An attempt has also been made to predict the range of the selection ogive; but here the agreement between prediction and experiment in the same two species was rather poor (Table 2). A survey was made of all available published selection ogives, from which a mean value for the range (R) in terms of the ratio R/L' was obtained—0·79 for roundfish, 0·53 for flatfish. These were further broken down into R_1 (the range 0–50 per cent retention) and R_2 (50–100 per cent); a mean for roundfish was calculated—$R_1=0{\cdot}53R$, $R_2=0{\cdot}44R$. For gwangwa, the selection in fact proved to be much sharper for R_2 than was predicted, and was in the region of $0{\cdot}26R$, while the inclusion in the cod-end of many very small fish stunned by the large and prevalent scyphomedusæ of these waters extended the ogive to the lower limit of the size-frequency distribution of the sample.

The great range in the values of S for these fish reflects the diversity of the commercial species and indicates the difficulty of reaching rational exploitation of such stocks; but it is hoped that it will be possible to use these predictions to determine, to some extent, the effect of mesh size in the now rapidly expanding Sierra Leone trawl fishery in which, subjectively, the size and fishing power of the fleet appears to be approaching the limit which the resources will stand.

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